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ORNL/RAP/Sub-87/99053/4&R1

Remedial Investigation Plan for ORNL Waste Area Grouping 1

Oak Ridge National Laboratory Remedial Investigation/Feasibility Study

REVISION 1

August 1989

U.S. Department of Energy
Oak Ridge Operations Office

Prepared by

Bechtel National, Inc.
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for

Oak Ridge National Laboratory

Operated by

Martin Marietta Energy Systems, Inc.

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REMEDIAL INVESTIGATION PLAN

FOR

ORNL WASTE AREA GROUPING 1

REVISION 1

AUGUST 1989

Report Prepared by
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P. O. Box 350
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for the
U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

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ACRONYMS

AA	Alternatives Assessment
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ARAR	Applicable or Relevant and Appropriate Requirement
BMAP	Biological Monitoring and Abatement Program
BNI	Bechtel National, Inc.
BSR	Bulk Shielding Reactor
CEC	Cation Exchange Capacity
CERCLA	Comprehensive Environmental Restoration, Compensation, and Liability Act
CLP	Contract Laboratory Program
CSL	Close Support Laboratory
CWA	Clean Water Act
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
ES&H	Environmental, Safety and Health
FDA	Food and Drug Administration
FHS	Field Health and Safety
FPDL	Fission Product Development Laboratory
FRC	Federal Regulatory Commission
FSP	Field Sampling Plan
FSS	Field Services and Support
GPR	Ground Penetrating Radar
HEPA	High Efficiency Particulate Air
HSWA	Hazardous and Solid Waste Amendments
IT	International Technology Corporation
LITR	Low Intensity Test Reactor
LLW	Low Level Waste
MCL	Maximum Concentration Limits
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration

ACRONYMS
(Continued)

ORGDP	Oak Ridge Gaseous Diffusion Plant
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PAM	Perimeter Air Monitoring
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PCB	Polychlorinated Biphenol
PIC	Pressurized Ionization Chamber
PVC	Polyvinylchloride
PWTP	Process Waste Treatment Plant
QA	Quality Assurance
QAA	Quality Assurance Assessment
QAM	Quality Assurance Manual
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAP	Remedial Action Program
RAS	Routine Analytical Services
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RSL	Radiological Science Laboratory
RTL	Review Team Leader
SARA	Superfund Amendments Reauthorization Act
SAS	Special Analytical Services
SDWA	Safe Drinking Water Act
SOP	Standard Operating Procedures
STP	Sewage Treatment Plant
SVOC	Semi-Volatile Organic Compound
SWDA	Solid Waste Disposal Area
SWMU	Solid Waste Management Unit
SWSA	Solid Waste Storage Area
TCL	Target Compound List

ACRONYMS
(Continued)

TDHE	Tennessee Department of Health and Environment
TDS	Total Dissolved Solids
TVA	Tennessee Valley Authority
USAEC	United States Atomic Energy Commission
USGS	U.S. Geological Survey
USRADS	Ultrasonic Ranging and Data System
VOC	Volatile Organic Compounds
WAG	Waste Area Grouping
WBS	Work Breakdown Structure
WOC	White Oak Creek
WOL	White Oak Lake
WQC	Water Quality Criteria

ABBREVIATIONS

Bq	Becquerel
Ci	curie
L	liter
MHz	megahertz
MM	modified Mercalli
MSL	mean sea level
R	roentgen
Sv	Sievert
°C	degrees Celsius
°F	degrees Farenheit
cfs	cubic feet per second
cm	centimeter
dpm	disintegrations per minute
ft	feet
g	gram
gal	gallon
h	hour
in.	inch
kV	kilovolt
kg	kilogram
km	kilometer
lb	pound
m	meter
mL	milliliter
mR	milliroentgen
mSv	milliSievert
meq	milliequivalent
mg	milligram
mg	milligram
mi^2	square miles
min	minute
mph	miles per hour
mrem	millirem
pCi	picocurie

ABBREVIATIONS
(Continued)

ppm	parts per million
psi	pounds per square inch
μR	microroentgen
μg	migrogram
yd^3	cubic yards
yr	year

1.0 INTRODUCTION

This document is the Remedial Investigation (RI) Plan for Waste Area Grouping (WAG) 1 of the U.S. Department of Energy's (DOE) Oak Ridge National Laboratory (ORNL), located near Oak Ridge, Tennessee. Figures showing the locations of Oak Ridge, ORNL, and WAG 1 are contained in Section 3.0. WAG 1 covers approximately 100 acres, comprising most of the main plant area of ORNL, and contains areas of known or suspected radiological and chemical contamination.

The December 1987 RI Plan prepared for WAG 1, the ORNL main plant area, presented discussions on the then 99 solid waste management units (SWMUs) within the WAG. Included in the discussion was an evaluation of the data on known radiological and chemical contaminants. From this evaluation, a field sampling plan (FSP) was developed. The initial plan was to collect data on the concentration of target compound list (TCL) constituents in the various environmental media associated with each SWMU and each potential migration pathway (i.e., groundwater, surface water, etc). This approach resulted in an extensive soil sampling effort not only around each SWMU but also in the areas adjacent to the SWMU in order to determine if contaminant plumes were leaving the SWMUs. This sampling configuration did not consider the influence of the shallow stormflow zone on the transport of materials from SWMUs to areas off site of WAG 1 and as a result the "unbiased sampling" design proposed in the original plan is now thought to be inappropriate to identifying plumes. The groundwater monitoring scheme, as proposed in the original WAG 1 RI FSP, included installation of a number of water quality monitoring wells, extensive sampling, and aquifer testing. These plans have been modified to utilize existing well systems and other access points to the groundwater to more accurately site the new wells needed to define the vertical and horizontal extent of possible groundwater contamination. Similarly, the originally proposed surface water and sediment sampling were designed without benefit of the present data. Both sampling efforts have been reconfigured to reflect present data needs.

The recent analyses of the inactive low-level waste (LLW) storage tank contents indicate the potential for widespread metal and organic contaminants since the materials in the tanks were transported through the LLW transfer pipeline system and the majority of the WAG 1 SWMUs are associated with that system. The anthropogenic structures within WAG 1 control and direct the flow of the shallow groundwater thus providing conduits for the movement of contaminants. Principal among these structures is the array of trenches containing not only the LLW pipelines but process and potable water and utility lines. The direction of movement of groundwater in the pipeline trenches is generally reflective of surface topography. However, the intricate crisscrossing of the various pipeline trenches can result in contaminants being transported considerable distances from the source.

The emphasis of the revised RI phase I field sampling effort is to provide data to establish the extent and concentrations of suspected contaminants to perform the baseline health assessment needed to define the requirements for remedial actions.

1.1 BACKGROUND

1.1.1 Regulatory Setting

DOE facilities, including ORNL, are required to be in full compliance with all federal and state environmental regulations. The initial guidance for remediation of contamination at ORNL was based on DOE Orders 5820.2 (Surplus Facilities Management) and 5480.14 [Comprehensive U.S. Environmental Restoration, Compensation, and Liability Act (CERCLA)]. The Resource Conservation and Recovery Act (RCRA) was believed to apply only to a limited number of sites. In a memorandum from the Environmental

Protection Agency (EPA) to DOE in April 1986, EPA elected to enforce regulatory requirements for ORNL remedial actions through its amended RCRA authority.

As currently implemented, the RCRA Section 3004(u) corrective action program consists of four phases (EPA 1986a):

1. The RCRA Facility Assessment (RFA) to identify releases or potential releases requiring further investigation

2. The RCRA Facility Investigation to fully characterize the extent of releases, (hereinafter referred to as the RI)

3. Corrective Measures Study to determine the need for and extent of remedial measures. This step includes identification of appropriate remedies for all problems identified

4. Corrective Measures Implementation to design, construct, operate, maintain, and monitor the performance of the measure(s) selected

1.1.2 <u>ORNL Remediation Strategy</u>

In response to the requirement for compliance with environmental regulations, ORNL, operated by Martin Marietta Energy Systems, Inc., (Energy Systems) has established a Remedial Action Program (RAP) to provide comprehensive management of areas where past and current operations have resulted in contamination of facilities or the environment. Under the ORNL RAP, corrective action will be implemented in the four phases identified in Section 1.1.1.

1.1.2.1 <u>RFA</u>. The RFA (Phase 1 of the RCRA corrective action process) was submitted to the EPA in March 1987. As the initial step in identifying compliance requirements, a complete listing of all known active and inactive waste management areas, contaminated facilities, and potential sources of continuing releases to the environment was prepared. Included in this list are waste collection and storage tanks, solid waste storage areas (SWSAs), waste treatment units, impoundments, and leak and spill sites. Although some of the sites are not regulated under RCRA Section 3004(u) (e.g., Surplus Facilities), they are included in the list to provide a comprehensive inventory of all ORNL sites that may represent actual or potential sources of continuing release to the environment.

Those actual or potential sources regulated under RCRA are referred to collectively as SWMUs.

Due to the large number of sites on the list (approximately 250), ORNL has combined the sites into 20 geographically contiguous and/or hydrologically defined units called Waste Area Groupings (WAGs). The WAG concept was developed to group the remedial action sites into manageable units that could be handled separately. There are a few areas where individual SWMUs remain outside WAG boundaries; however, this approach avoids artificially expanding the area of a WAG to include outlying SWMUs. In some cases, there has been hydrologic interaction among SWMUs within a WAG, thus making some SWMUs hydrologically inseparable. Grouping SWMUs allows WAG perimeter monitoring of both groundwater and surface water at inflow and discharge points to determine if contaminants are migrating from the WAG. Based on WAG perimeter monitoring data, further studies (principally directed toward the groundwater subsystem) may address individual SWMUs or groups of SWMUs within a WAG, as well as contaminant plumes, that extend beyond the perimeter of the WAG.

1.1.2.2 RI/FS. Under the ORNL RAP, the second and third phases of corrective action will be incorporated in a Remedial Investigation/Feasibility Study (RI/FS) for the entire ORNL complex. For the ORNL RI/FS, a separate RI and Alternatives Assessment (AA) will be performed for each WAG. At the conclusion of these separate studies, the AAs and any generic studies (studies that impact multiple WAGs) will be combined to form a single, comprehensive ORNL FS, which will be functionally equivalent to an Environmental Impact Statement (EIS).

Energy Systems has contracted with Bechtel National, Inc. (BNI) and its subcontractors, CH2M HILL, EDGe/MCI, and PEER Consultants (the BNI Team) to perform the ORNL RI/FS.

1.2 PURPOSE AND SCOPE

1.2.1 Objectives

The primary objectives of the WAG 1 RI Plan are to document the RI planning process and to specify the scope, procedures, and materials for performing the RI.

The site-specific overall objectives of the actual RI are to:

- Collect data of sufficient quality and quantity to define the nature and extent of contamination within WAG 1 and, to the extent possible, the nature and extent of contamination associated with individual SWMUs or groups of SWMUs
- Determine if contamination within WAG 1 has migrated, or has the potential to migrate, beyond the WAG 1 boundary; and if it has migrated, determine the extent of migration
- Perform baseline human exposure and environmental assessments to define and prioritize those SWMUs or groups of SWMUs within WAG 1 requiring remediation
- Collect sufficient contamination characterization and engineering data to develop and evaluate a range of remedial alternatives for SWMUs and general environmental contamination requiring remediation

1.2.2 Scope

The scope of this document is described in two parts. The first part pertains to the RI planning process; the second part pertains to the specification of RI activities.

1.2.2.1 Planning Process. The RI planning process conforms to the following EPA documents:

- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (Draft, October 14, 1987)
- Data Quality Objectives for Remedial Response Activities, Volume 1 - Development Process (March 24, 1987)

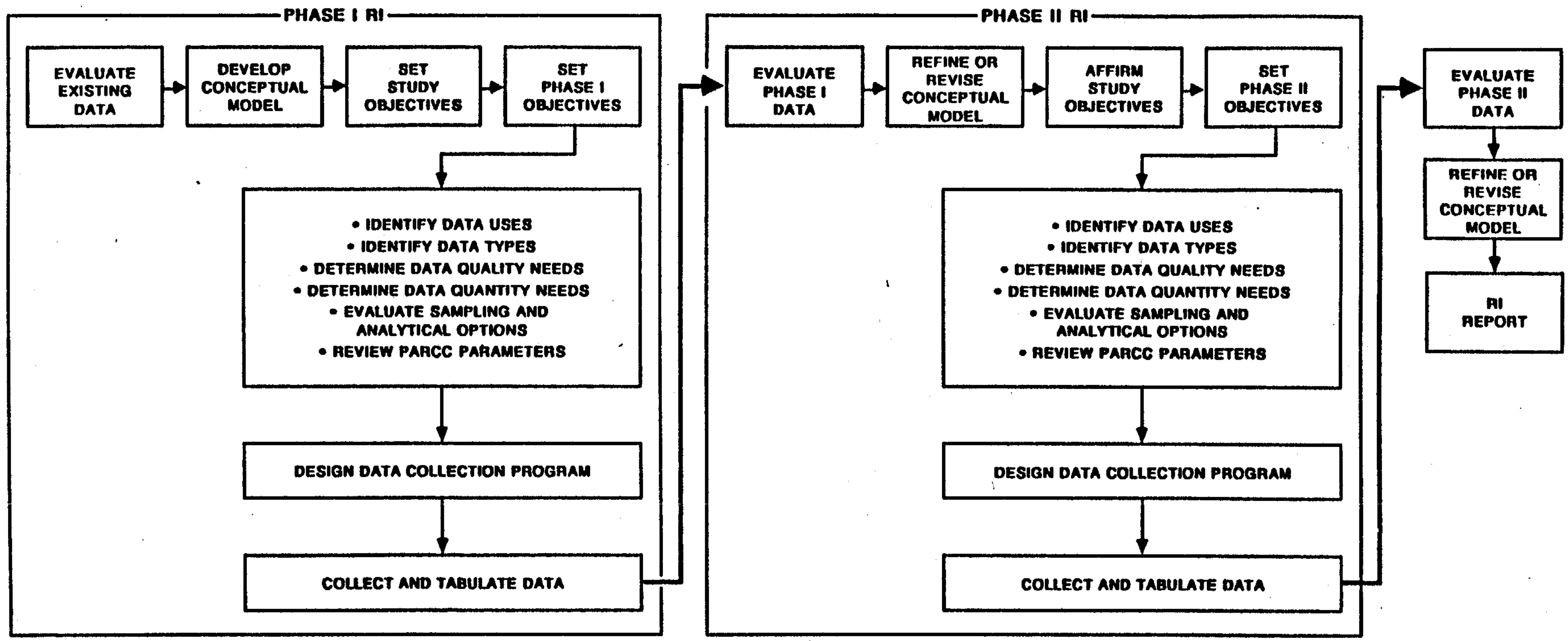
More specifically, the scope of the planning process includes performing the following four general steps:

- o Determine the types of remedial decisions to be made regarding WAG 1
- o Identify the data needed to support those decisions
- o Describe the methods by which the data, once collected, will be analyzed for use by decision makers
- o Develop the methods by which the data will be obtained

The WAG 1 RI planning process is predicated on an iterative approach, an example of which is illustrated in Figure 1-1. In an iterative process, data can be collected in stages. With initial RI activities generally focused on developing a good understanding of the site, subsequent iterations can be focused on filling data gaps. The iterative process allows identification of key data needs as early in the process as possible and ensures that data collection is always directed toward providing information necessary for ultimate selection of a remedial action.

1.2.2.2 <u>Summary Description of RI Plan</u>. Based upon the objectives defined above, a review of the operating history of the ORNL Main Plant, and a review of past characterization studies of WAG 1, data needs have been identified that will aid in resolving the following technical issues:

- o The types and locations of radionuclides within and beyond the WAG 1 boundary
- o The types and locations of chemical contaminants within and beyond the WAG 1 boundary
- o The contribution of sediments and surface soil contamination to surface water contamination
- o The interaction of the groundwater and surface water flow regimes in the migration of contamination



SOURCE: Adapted from Data Quality Objectives for Remedial Response Activities, EPA/540/G-87/004.

FIGURE 1-1
EXAMPLE OF ITERATIVE APPROACH TO RI

- The nature of lateral and vertical flow within and between shallow and deep aquifers

A sampling plan has been developed to collect additional data, refine the understanding of the above technical issues, perform a baseline risk assessment, and develop and evaluate remedial alternatives. The following general types of data will be collected:

- Civil surveys will be conducted to designate the location of specific sampling sites.
- Surface radiological surveys will be used to assist in determining soil sampling locations.
- EM-31 will be employed in SWSAs 1 and 2 and in the Waste Pile area to aid in determining the location of trenches and waste forms. It also will be used to aid in pipeline locations in areas where sampling will be undertaken.
- X-ray fluorescence will be used to determine the presence of heavy metal constituents in soils and sediment. This effort will be used to screen for suspected contamination in areas possibly requiring more extensive sampling.
- Headspace gas analysis will be used in water quality and piezometer wells to determine the presence of volatile organic chemicals and to focus subsequent groundwater and subsurface soil sampling.
- Surface and subsurface soils sampling will be conducted in areas to provide radionuclide and chemical contaminants data. These areas initially will be identified during the nondestructive survey phase.
- Building sumps and tank drywells will be inventoried and sampled as required to provide information on possible groundwater contaminants.
- Personnel exposure information will be obtained from existing ORNL records or from monitoring conducted during the RI effort.
- The existing groundwater well network will be used, where possible, to define the nature, distribution, and movement of contaminants in groundwater. Additional groundwater monitoring wells will be installed, if needed, to more completely evaluate the groundwater flow systems and contaminant transport therein.

- Surface water and sediments in the three major streams within WAG 1 will be sampled. Opportunistic samples will be collected in areas appropriate to refining information on contaminant distribution and migration.

As previously described, development of data to achieve the RI objectives will probably require more than one phase of remedial investigation. There are many potential contaminants, and the pathways are complex and not fully understood at this time. Also, not all applicable or relevant and appropriate requirements (ARARs) can be defined until additional data are available. (A list of the ARARs identified to date is provided in Section 4.0.) It is possible that risk-based limits might have to be developed if they are not currently available.

The analytical protocols selected for this RI effort are EPA's Contract Laboratory Program (CLP) Routine Analytical Services (RAS) procedures for TCL compounds. Special Analytical Services (SAS) procedures will be utilized if non-TCL compounds are identified as being possible contaminants.

The next iteration of the RI will utilize the data developed during, or following, the implementation of this plan to direct attention to specific contaminants of concern and/or specific areas within the WAG that may require special analytical procedures.

1.3 ORGANIZATION AND APPROACH

The scope of work for the WAG 1 RI was developed in conformance with guidelines established by EPA for the conduct of remedial investigations. Figure 1-2 illustrates the process followed and how it is documented in this RI Plan.

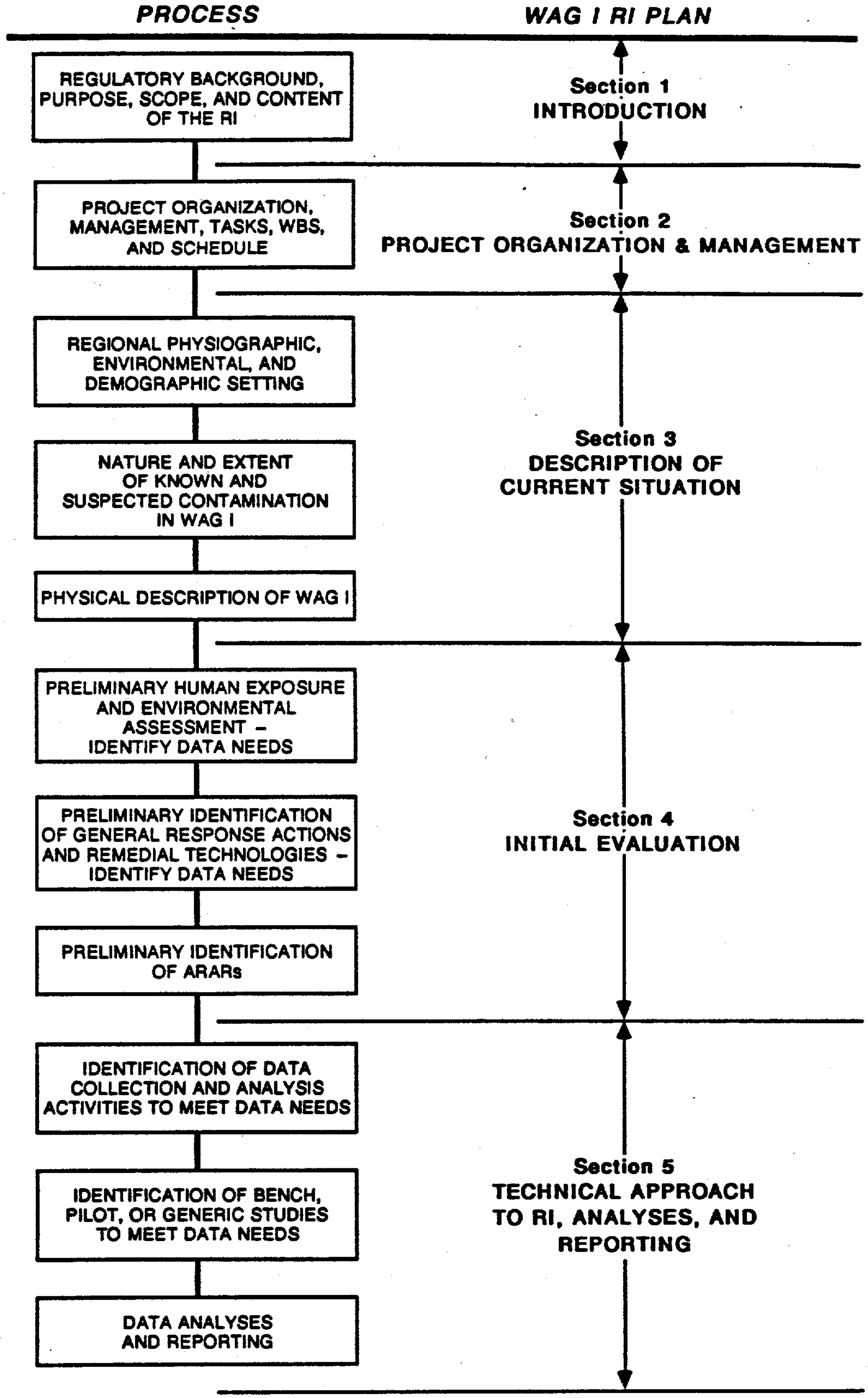


FIGURE 1-2
APPROACH TO DEVELOPMENT OF RI PLAN

The RI Plan consists of five sections and three appendices. In general, the text of the plan describes the RI planning and management process, and the appendices describe the protocols for data collection and evaluation. The following paragraphs indicate the content of each RI Plan section and appendix.

Section 1.0 introduces the RI Plan and the RI process. Section 2.0 describes the project organization and management; provides brief descriptions of the RI tasks and their integration into a project Work Breakdown Structure (WBS); and presents the preliminary schedule. Section 3.0 evaluates available site and contaminant characterization data. Section 4.0 is an initial evaluation of specific data uses and the corresponding data needs. (To identify these data uses and needs, a preliminary human health and environmental assessment was performed and a preliminary list of remedial technologies that may be applicable to the site was developed. From these efforts, specific data requirements were identified.) Section 5.0 presents the technical approach adopted for collection and analysis of the data identified in Section 4.0.

Appendix A is the Field Sampling Plan (FSP), which contains a detailed description of field activities to be performed during the RI; the Quality Assurance Project Plan (QAPP), which presents the policies, organization, and specific activities designed to achieve the data quality goals of the project; and the Waste Management Plan, which describes procedures for handling and disposing investigation-derived wastes and estimates the quantity of waste to be generated during field activities.

2.0 PROJECT ORGANIZATION AND MANAGEMENT

This section of the RI Plan presents the WAG-1-specific project organization and management plan, which is derived from the RI/FS Project Management Plan (BNI, 1987). Section 2.1 presents the organization, responsibilities, and staffing for the RI. Section 2.2 describes the coordination and liaison interfaces with Energy Systems. Section 2.3 discusses basic Quality Assurance (QA) approaches. Section 2.4 lists and summarizes the WAG 1 RI tasks and identifies the tasks according to the WBS established for the WAG 1 RI, and Section 2.5 presents the preliminary schedule for performance of the RI. Sections 2.6 and 2.7 discuss the plans for WAG 1 data base management and ES&H activities, respectively.

2.1 ORGANIZATION, RESPONSIBILITIES, AND STAFFING

Figures 2-1 and 2-2 illustrate the organizational structures for Energy Systems and the BNI Team. Responsibilities and authorities for the WAG 1 team are briefly described below.

WAG Manager. The WAG Manager is accountable for budget, schedule, and quality of performance during the WAG 1 Remedial Investigation. Specifically, the WAG Manager is responsible for the management of all remedial investigation planning, field investigations, and data analysis for WAG 1. The WAG 1 Manager will be expected to interact with Energy Systems staff frequently as work progresses.

Technical Support. A cadre of engineers, hydrogeologists, scientists, and other specialists on the BNI Team will process and analyze data, recommend revisions to the sampling plan as needed, monitor the construction of sampling stations, and provide consultation to field personnel. These specialists will be drawn as needed from the pool of professionals maintained under the RI/FS Manager. They will report to the WAG 1 Manager when performing WAG-1-specific work.

Field Services and Support (FSS) Manager. The FSS Manager will direct field and support activities for the work on all WAGs in accordance with approved plans and procedures. The FSS Manager will help develop schedules for various work elements. With a thorough understanding of the required work and schedules for each WAG, the FSS Manager will integrate requirements for each WAG into a

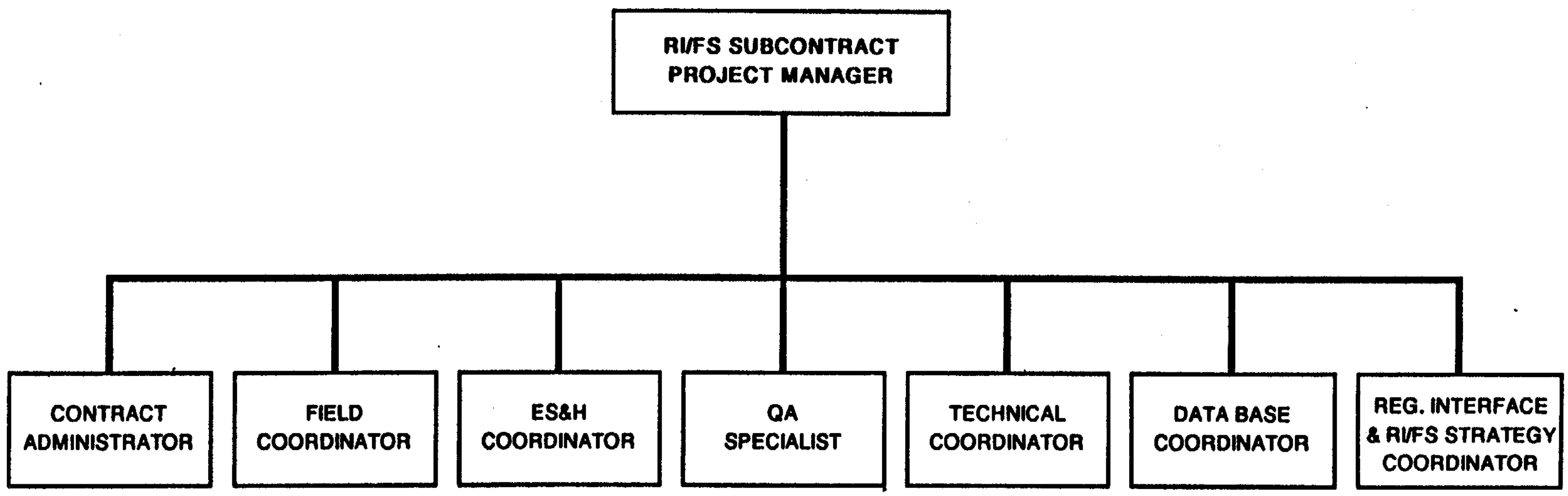


FIGURE 2 – 1
ENERGY STSTEMS RI/FS PROJECT MANAGEMENT TEAM

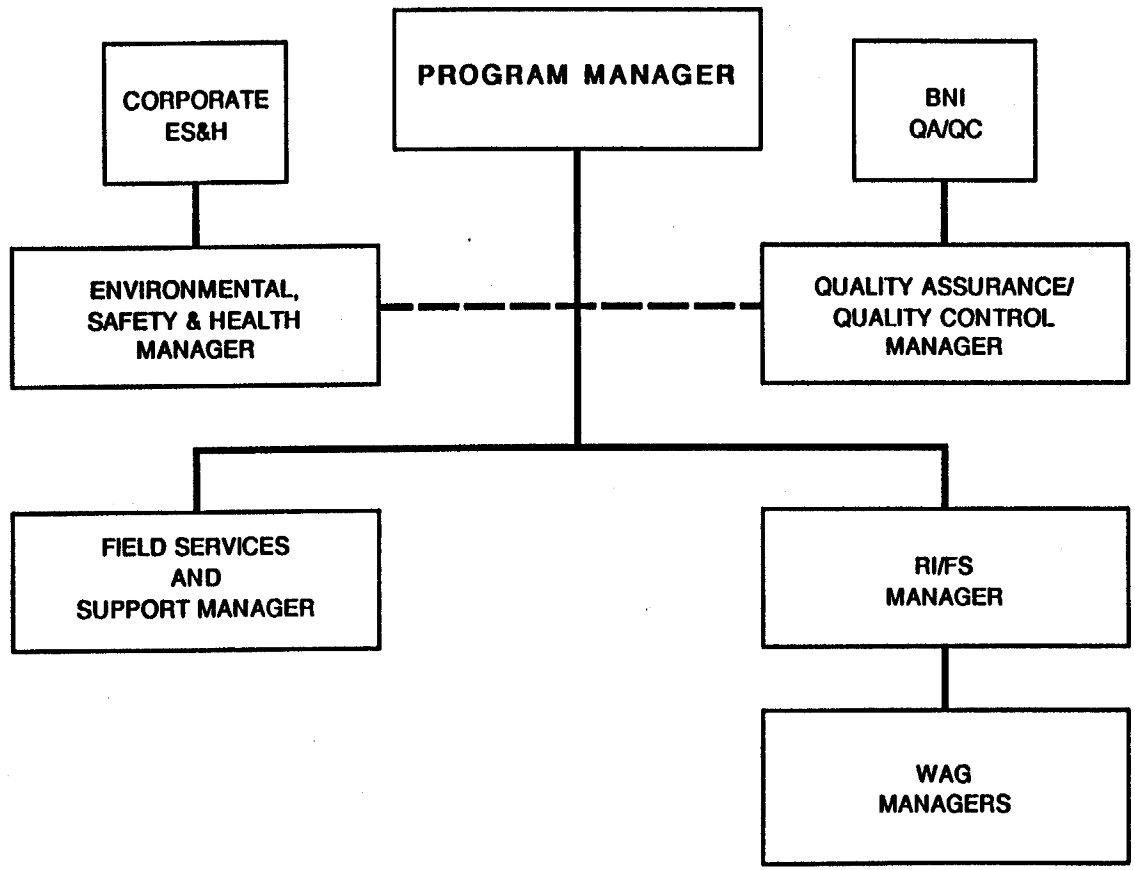


FIGURE 2-2
RI/FS SUBCONTRACTOR ORGANIZATION

RIFS 004

comprehensive planning schedule. This schedule will identify peaks and will allow long-range planning for efficient use of resources. The FSS Manager will be supported by technical and administrative staff as dictated by field conditions.

Field Quality Control (QC) Supervisor. The Field QC Supervisor is independent from the project organization and reports directly to the RI/FS project QA Manager. The Field QC Supervisor monitors the WAG 1 QAPP implementation and works with the WAG 1 Manager to coordinate the program's application. He will perform system and performance audits and ensure the satisfactory implementation of any required corrective action resulting from the audits. He will also monitor drilling crews, on-site laboratory staff, and other field personnel to ensure that their activities are being conducted in accordance with the RI Plan. His authority includes the right to stop work.

Laboratory QC Supervisor. The Laboratory QC Supervisor reports directly to the RI/FS project QA Manager. The Laboratory QC Supervisor monitors the performance of laboratory analyses through inspection of laboratory operations (from sample receipt to data reporting) and through data assessments. The Laboratory QC Supervisor checks data and data packages to ensure that all requirements have been met for precision, accuracy, representativeness, comparability, and completeness.

Field Health and Safety (FHS) Supervisor. The FHS Supervisor is responsible for implementing the Environemtnal, Safety and Health (ES&H) program in the field. He evaluates health and safety concerns at the site level and applies the requirements specified in the project ES&H Plan and procedures. In performing his evaluations, the FHS Supervisor shall solicit technical assistance from the ES&H Manager when conditions exist that are not covered by existing plans and procedures. Through discussions with the FSS Manager, the FHS Supervisor determines the schedule of activities and deploys available resources to provide required health and safety coverage.

Review Team Leader. The responsibilities of the Review Team Leader (RTL) are described in RI/FS Project Procedure 1311, "Review Team Leader." The RTL is chosen from among senior RI/FS project management not directly connected to the WAG 1 RI effort. The RTL serves as an independent source for technical review of key phases of the RI, promoting consistency and quality of philosophy, technical approach, and methodologies. The RTL concept also serves the RI/FS project need for transfer of information among WAG teams and aids in planning and guidance of WAG activities.

Staffing for WAG Manager and FSS Manager positions is listed in the Project Management Plan (BNI, 1987). Other positions will be staffed with personnel assigned to the RI/FS project team under the sponsorship of BNI, EDGe/MCI, CH2M HILL, and PEER Consultants.

2.2 COORDINATION/LIAISON

Successful implementation of the WAG 1 RI requires close communication and coordination between Energy Systems and the BNI Team. The WAG 1 Manager will be expected to interact with Energy Systems staff frequently as work progresses. His normal day-to-day interface with Energy Systems will be with the RI/FS Subcontract Management Team Technical Coordinator. Overall WAG 1 interfaces are illustrated in Figure 2-3.

Before any field activities begin, the FSS Manager will interface with the FHS Supervisor, Field QC Supervisor, and WAG Managers to ensure that all proposed operations conform to approved plans, procedures, and requirements. He will be responsible for coordinating field activities with the Energy Systems Field Coordinator. The FSS Manager will also routinely update Energy Systems on the status of ongoing and planned operations. The FSS Manager will inform the Field Coordinator of the plans, timing, personnel, and equipment utilization related to field activities so that applicable requirements can be met for access, excavation permits, and hazardous work permits. He will work with the WAG Managers to resolve schedule conflicts among WAGs with concurrent activities.

The FSS Manager will also work with the Energy Systems Field Coordinator in interfacing with the ORNL staff for coordinating RI/FS activities with routine plant operations and emergency response needs.

Interfaces regarding waste management will be coordinated through the Energy Systems Field Coordinator. These interfaces are described in more detail in the RI/FS project Waste Management Plan (BNI, 1987a). Interfaces relating to health and safety will be coordinated through the Energy Systems RI/FS Subcontract Management Team ES&H Coordinator. These interfaces and emergency response interfaces are described in the ES&H Plan (BNI, 1987b).

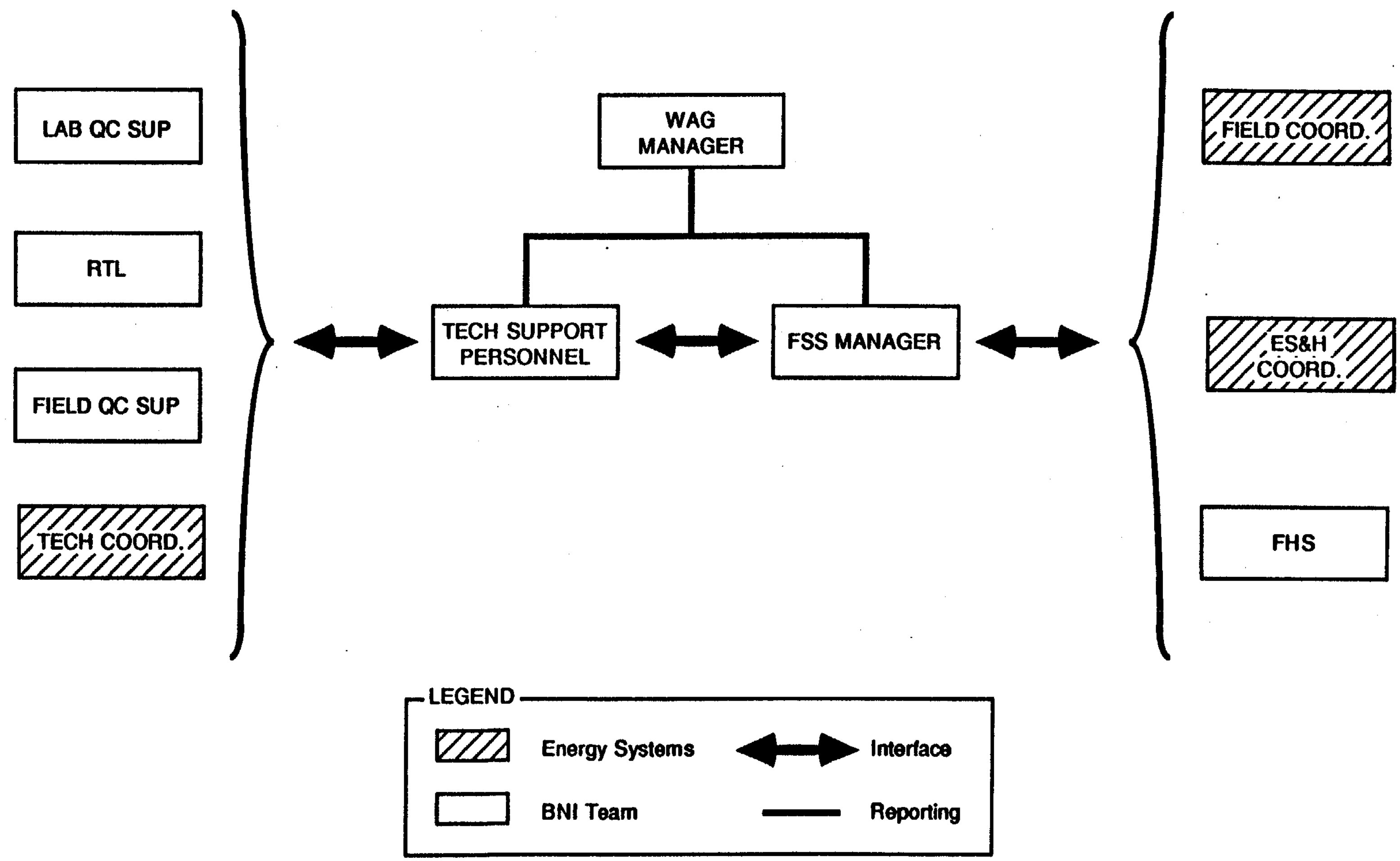


FIGURE 2-3
WAG I RI ORGANIZATION AND INTERFACES

L-84

2.3 QUALITY ASSURANCE APPROACH

The ORNL RI/FS project is committed to implementing a Quality Assurance Program that complies with the requirements of DOE and EPA. Specifically, these requirements are ANSI/ASME-NQA-1-1986 Edition, Quality Assurance Program Requirements for Nuclear Facilities, and QAMS-005/80, Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans, respectively.

NQA-1 is the predominant Quality Assurance Program standard for the project and is the basis for the project Quality Assurance Plan (QAP) (BNI, 1987c). All project documents and activities affecting the performance of RI/FS activities must comply with the QAP. NQA-1 has 18 criteria, all of which are applicable to the RI/FS project.

QAMS-005/80 is the standard used to form the basis for the specific QA and QC activities to achieve the WAG-specific data quality goals. QAMS-005/80 has 16 criteria, all of which are applicable to site monitoring and measurement activities. The requirements of QAMS-005/80 will be contained in the QAPPs. The WAG 1 QAPP describes the procedures used to document and report precision, accuracy, and completeness of environmental measurements. Figure 2-4 is a matrix showing the relationship of ANSI/ASME NQA-1, as applied in the QAP, and EPA QAMS-005/80, as applied in the QAPP.

NQA-1 contains four criteria that are not directly applicable to site monitoring and measurement activities and will not be found in the QAPP. Specifically, Design Control (3), Procurement Document Control (4), Document Control (6), and Control of Purchased Items and Services (7). However, the four criteria are addressed in the QAP and will be applied on a project-wide basis.

Figure 2-5 presents a graphic description of the interfaces among the primary participants in the RI/FS project.

EPA QAMS — 005/80 (QAPP)

ANSI/ASME-NQA-1 CRITERIA (QAP)	1 TITLE PAGE	2 TABLE OF CONTENTS	3 PROJECT DESCRIPTION	4 PROJECT ORGANIZATION & RESPONSIBILITY	5 QA OBJECTIVES FOR MEASUREMENT DATA	6 SAMPLING PROCEDURES	7 SAMPLE CUSTODY	8 CALIBRATION PROCEDURES & FREQUENCY	9 ANALYTICAL PROCEDURES	10 DATA REDUCTION, VALIDATION, & REPORTING	11 INTERNAL QC CHECKS & FREQUENCY	12 PERFORMANCE & SYSTEM AUDITS & FREQUENCY	13 PREVENTIVE MAINTENANCE PROCEDURES & SCHEDULES	14 SPECIFIC ROUTINE PROCEDURES*	15 CORRECTIVE ACTION	16 QUALITY ASSURANCE REPORTS
1 ORGANIZATION				●												
2 QUALITY ASSURANCE PROGRAM			●													
3 DESIGN CONTROL																●
4 PROCUREMENT DOCUMENT CONTROL																
5 INSTRUCTIONS, PROCEDURES & DRAWINGS						●	●	●	●	●			●	●		
6 DOCUMENT CONTROL																
7 PURCHASED ITEMS & SERVICES CONTROL																
8 ITEMS IDENTIFICATION & CONTROL							●									
9 PROCESSES CONTROL						●		●	●		●		●			
10 INSPECTION											●					
11 TEST CONTROL											●					
12 MEASURING & TEST EQUIPMENT CONTROL								●								
13 HANDLING, SHIPPING & STORAGE						●	●									
14 INSPECTION, TEST & OPERATING STATUS						●			●	●		●				
15 NONCONFORMING ITEMS CONTROL															●	
16 CORRECTIVE ACTION															●	
17 QUALITY ASSURANCE RECORDS																●
18 AUDITS												●				

* TO BE USED TO ASSESS DATA PRECISION, ACCURACY, AND COMPLETENESS OF SPECIFIC MEASUREMENT PARAMETERS INVOLVED

FIGURE 2-4
MATRIX OF THE RELATIONSHIP OF
ANSI/ASME NQA-1 AND EPA QAMS 005/80

C23/RIFS19

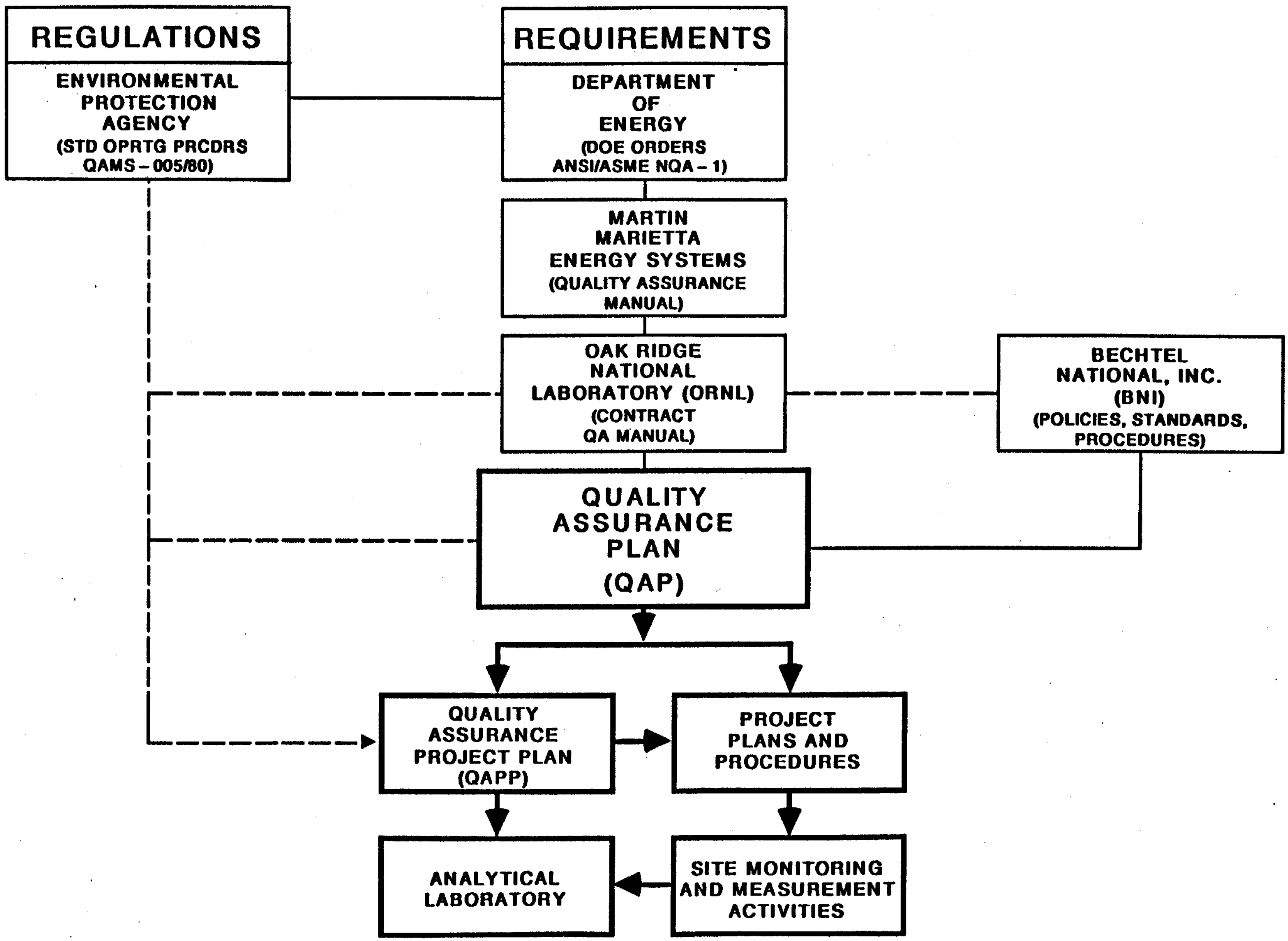


FIGURE 2-5
QUALITY ASSURANCE PROGRAM INTERFACES
AMONG PARTICIPANTS IN ORNL RI/FS

RIFS 016

The RI/FS project QAP (BNI, 1987c) presents the project-wide QA program that establishes policies, procedures, standards, guidelines, and training aimed at producing a quality product. It is the responsibility of the WAG 1 Manager to apply these measures to maintain an acceptable level of quality during the WAG 1 RI.

The WAG 1 Manager also has the responsibility for developing the RI Plan using a data-quality-objective process so that RI objectives are achieved. The QAPP establishes the specific quality control requirements and criteria for the WAG 1 RI, especially for the implementation of the FSP. The WAG 1 FSP and QAPP are included in Appendix A. The technical approach is discussed in Section 5.0. The paragraphs below discuss the quality measures being applied to WAG 1.

The Field QC Supervisor and the Laboratory QC Supervisor will verify that the quality requirements described in the RI Plan and referenced project documents are being satisfactorily implemented in accordance with the QAP.

A formal Quality Assurance Assessment (QAA) will be performed in accordance with the QAP for WAG 1 to identify and evaluate the risk of potentially significant quality problems (failure modes), to plan for their prevention, or to minimize the consequences should they occur.

Quality Assurance project audits will be conducted in accordance with the QAP to verify compliance with all aspects of the RI. These audits will include project office, field, and/or laboratory quality-related activities. These audits will be planned, scheduled, and performed in accordance with Project Procedure 1307, "Project Audits."

The RTL and a team of selected senior reviewers will participate in periodic reviews of WAG 1 planning, analysis, and reporting. At a minimum, the review team will review the following interim and final deliverables in draft form before release to Energy Systems:

- Technical Letter Reports
- Draft RI Report
- Final RI Report

2.4 WAG 1 TASKS, WORK BREAKDOWN STRUCTURE, AND SCHEDULE

This section summarizes the administrative and technical activities that will be performed by the BNI Team as part of the WAG 1 RI; identifies the tasks according to the WBS established for WAG 1; and presents the preliminary schedule for the RI. Standard tests, as defined in the REM IV Work Plan Guidance Handbook (EPA, 1986), and those tests developed specifically to meet the needs of the individual WAGs, were used in developing the WAG 1 RI Plan. Standard tasks are assigned to the fifth level of reporting in the WBS; groups of standard tasks are assigned to the fourth level of reporting.

Tasks included in the WAG 1 scope and their WBS designations are presented in Figure 2-6 and are briefly described below. Figure 2-7 depicts the responsibility assignments for accomplishing the tasks.

WBS 201100: RI PLAN PREPARATION

This task provides for the preparation of this RI Plan and any revisions and/or addenda required to meet the overall project objectives. If, at the conclusion of the work outlined herein, additional data needs are identified, this task would be used to collect costs to prepare future RI planning documents.

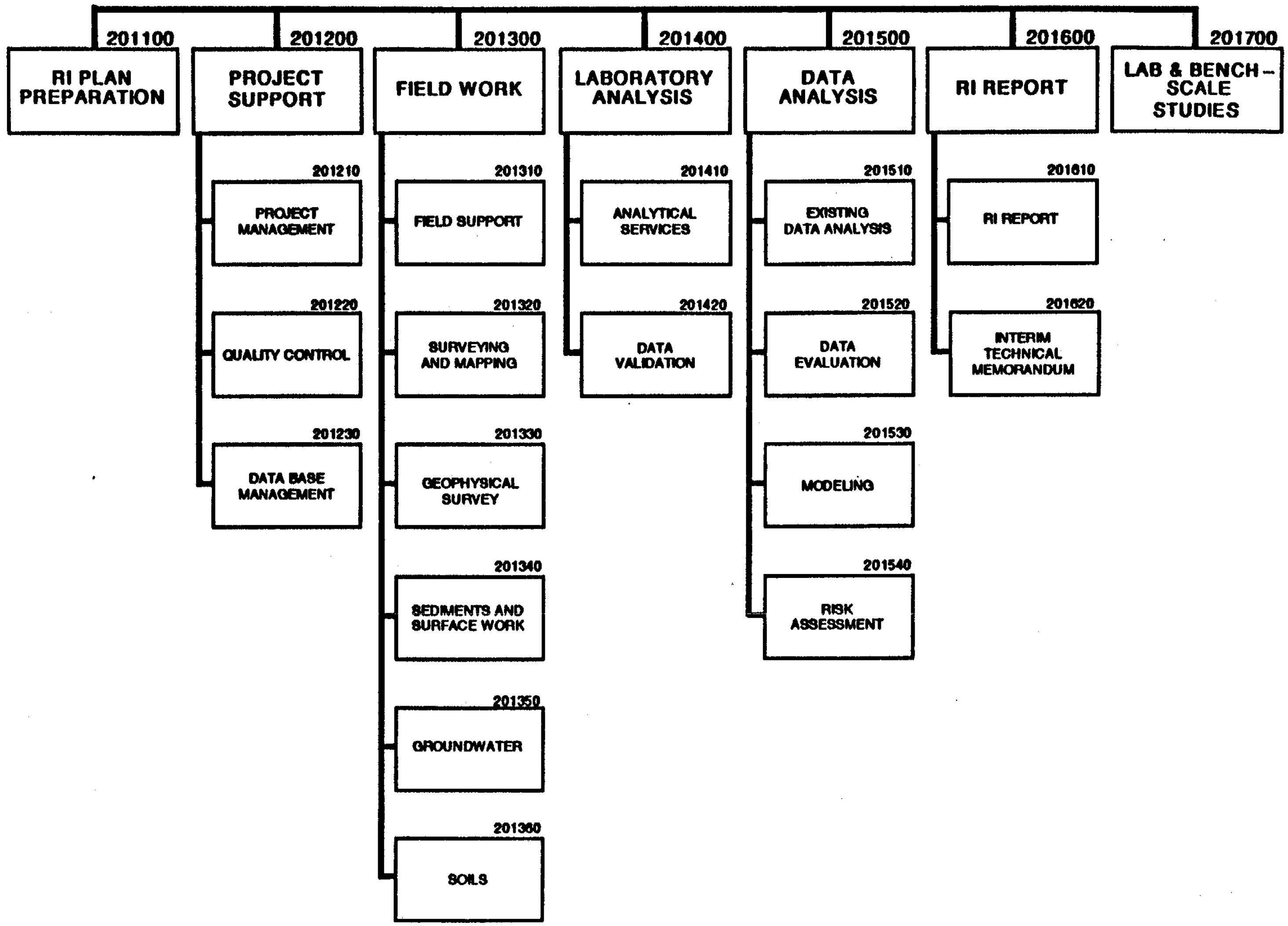


FIGURE 2-6
WORK BREAKDOWN STRUCTURE FOR WAG I

WORK BREAKDOWN STRUCTURE							FSS MGR.	WAG MGR.	ES&H MGR.
WBS LEVEL					ELEMENT ID	ELEMENT DESCRIPTION			
1	2	3	4	5					
		X			201000	WAG I RI		●	
			X		201100	RI PLAN		●	
			X		201200	PROJECT SUPPORT		●	
				X	201210	PROJECT MANAGEMENT		●	
				X	201220	QUALITY CONTROL		●	
				X	201230	DATA BASE MANAGEMENT		●	
			X		201300	FIELD WORK		●	
				X	201310	FIELD SUPPORT	●		
				X	201320	SURVEYING & MAPPING	●		
				X	201330	GEOPHYSICAL SURVEY	●		
				X	201340	SEDIMENTS AND SURFACE WATER	●		
				X	201350	GROUNDWATER	●		
				X	201360	SOILS	●		
			X		201400	LABORATORY ANALYSIS		●	
				X	201410	ANALYTICAL SERVICES			●
				X	201420	DATA VALIDATION			●
			X		201500	DATA ANALYSIS		●	
				X	201510	EXISTING DATA ANALYSIS		●	
				X	201520	DATA EVALUATION		●	
				X	201530	MODELING		●	
				X	201540	RISK ASSESSMENT		●	
			X		201600	RI REPORT		●	
				X	201610	RI REPORT PREPARATION		●	
				X	201620	INTERIM TECHNICAL MEMORANDA		●	
			X		201700	LAB AND BENCH-SCALE STUDIES		●	

RIFS 010

FIGURE 2-7
RESPONSIBILITY ASSIGNMENT MATRIX
FOR THE WAG I RI

WBS 201200: PROJECT SUPPORT

Project support includes Project Management, Quality Control, and Data Base Management tasks.

Project Management. Project management activities will include the direction of all technical and administrative aspects of the WAG 1 RI. These activities include preparation of monthly status reports; client meetings; controlling budget and schedule; selecting, coordinating, and scheduling staff for individual task assignments; maintaining project quality control and assurance programs; weekly meetings with other WAG Managers; providing environmental safety and health controls; and maintaining a waste management program.

Quality Control. Periodic quality reviews of project plans, ongoing project activities, project files, and project deliverables will be conducted by the RTL. Field inspections will be conducted by QC supervisors on a routine basis, and QA audit teams will conduct periodic audits. QAAs will be performed by the WAG Manager.

Data Management. Data management will be performed as specified in the Data Base Management Plan (BNI, 1987d). Both validated existing data and data generated as part of the RI will be entered into the project data base to allow effective comparisons based on factors such as type of sample, location, parameter, and concentration. Invalid data will not be entered into the data base, but will be stored on tape.

WBS 201300: FIELD WORK

Field Work includes activities associated with implementing the FSP. As shown in Figure 2-6, the standard tasks include Field Support, Surveying and Mapping, Geophysical Survey, Surface Water and Sediments, Groundwater, and Soils. These tasks are briefly described in the following paragraphs.

Field Support. Field support for the implementation of field activities of the WAG 1 RI will be coordinated through the FSS Manager. WAG-specific field activities, identified during planning as necessary for the satisfactory completion of the RI, will be implemented by the FSS Manager under the direction of the WAG 1 Manager. As part of the field support activities, site-specific plans for environmental safety and health, waste management, and sample measurement will be prepared prior to initiation of any field activities.

Civil Surveying and Mapping. Civil surveys will be performed in preparation for the other nondestructive surveys and for preliminary and final location and elevation of sampling points. The civil surveys will also support required permitting procedures; establish post-installation locations and elevations of new wells, boreholes, weirs and gauges; and provide information on general site features and facilities. The FSP describes the objectives of the civil survey in detail.

Nondestructive Surveys. The WAG 1 RI field activities involve a series of nondestructive surveys. These include: 1) a radiation walkover survey, 2) a series of efforts involving data for establishing personnel exposures, 3) an EM-31 survey of SWSAs 1 and 2 and the waste pile area, 4) a survey for heavy metal contaminants utilizing field portable x-ray fluorescence, and 5) an inventory of building sumps and tank drywells.

Sediments and Surface Water. Sediment sampling field work includes collecting sediment samples from the channels of each of the existing creeks, historic and existing floodplains, and the sewage lagoons. Specific activities are described in the FSP.

Groundwater. The groundwater field work will include: evaluating and upgrading wells in the existing well network; performing headspace gas analysis on the existing well systems; collecting three rounds of groundwater samples; and obtaining discrete and continuous water level measurements. Details of the groundwater field work are described in the FSP.

<u>Soils</u>. The soil sampling field work is divided into three distinct activities:

- o Soils I - localized areas defined during the nondestructive surveys and well headspace gas analysis; these include spill and leak sites, SWSA 1, SWSA 2, and possibly the waste pile area.
- o Soils II - areas identified as a result of the creek sediment survey and the headspace analysis of existing wells; primarily these will involve defining major migration routes.
- o Soils III - those locations determined by the previous soil sampling activities to be source terms in need of more extensive definition.

Details of the soils field work are described in the FSP.

<u>WBS 201400: LABORATORY ANALYSIS</u>

A summary of the samples to be collected as part of the WAG 1 RI is provided in Table A1-1 of the FSP. Sampled media include surface water, sediments, soils, and groundwater. Standard tasks included as part of laboratory analysis are Analytical Services and Data Validation, which are described below.

<u>Analytical Services</u>. Laboratory analytical support will be provided by International Technology (IT) Corporation through a close-support field laboratory and their three permanent laboratories located in the Oak Ridge/Knoxville area. The on-site

field laboratory will facilitate rapid screening of samples; the off-site permanent laboratories will perform analyses meeting levels of Analysis IV and V (as defined in EPA 540/G-87/003). Samples will initially be sent to the close-support laboratory for screening to identify indicator parameters that will determine the need for additional analyses; determine how samples should be processed; and determine to which off-site permanent laboratory the sample will be shipped. The analytical support laboratory will provide all sample containers, preservatives, trip blanks, labels, and bar-coded container tags.

Laboratory Data Validation. Laboratory analytical data will be reviewed for contract compliance and general data quality by the Laboratory QC Supervisor or designee. Data validation will be performed by an independent contractor. This activity will include the analysis of results from blanks, duplicates and replicates, spike recoveries, and standards. Appropriate use of the analytical data for RI/FS purposes will be evaluated by project personnel. Limitations of the analytical data will be presented and explained in the RI report.

WBS 201500: DATA ANALYSIS

Data Analysis includes standard tasks Existing Data Analysis, Data Evaluation, Modeling, and the Risk Assessment. These tasks are described in the following paragraphs.

Existing Data Analysis. This task includes activities necessary to evaluate existing data that were identified during the RI planning activities but which were unavailable to the RI planning team at that time. These data will include information needed to finalize the FSP and support the field investigations. Existing data collected as part of the task will be technically validated. If the evaluation of existing WAG-specific field and analytical data or results of ongoing ORNL studies indicates a need to modify the FSP, these modifications will be identified and appropriate steps taken to incorporate them into the FSP.

Data Evaluation. All data will be summarized and evaluated. Plots, contours, and maps will be revised and/or developed to assist in data explanations and presentations. All RI objectives will be reviewed to determine if the gathered data provide the specific information required by each task. Limitations will be identified and documented in the RI Report.

Modeling. Data developed as part of the RI and entered into the project data base will be manipulated using appropriate geochemical, groundwater flow, and contaminant transport models to predict the distribution of various contaminants over time under differing hydrologic and hydraulic conditions. Geochemical software such as PHREEQE may be used to predict speciation and potential mobility of various contaminants. Flow models may be used to address groundwater flow, direction, and rate. Contaminant transport analytical models may also be utilized in the analysis.

Risk Assessment. Data collected from existing sources and from the RI will be evaluated to determine whether substances found at the site present a threat or potential threat to public health, public welfare, or the environment under the No Action alternative and future site development situations. Existing standards, guidelines, and ARARs will be reviewed to develop a range of estimates of potential threats from SWMUs or groups of SWMUs within WAG 1 to public health, welfare, or the environment. The results of the risk assessment will be included as a chapter in the RI Report. Supporting risk, transport, and data calculations will be appended, and relevant references will be cited.

WBS 201600: REMEDIAL INVESTIGATION REPORT PREPARATION

Standard tasks RI Report and Technical Interim Memoranda are included in this activity.

RI Report. A report summarizing and interpreting the WAG 1 RI activities will be prepared and provided to Energy Systems. The report will provide documentation of data that is obtained, as well as a discussion of data evaluation and associated limitations. Preparation of two drafts and one final version of the RI Report are included as part of this task.

Technical Interim Memoranda. During the course of performing the RI tasks, it may become necessary to issue interim technical letter reports summarizing selected RI activities or data generated as part of the RI activities and identification of additional data needs. As a minimum, a letter report will be issued at the end of each fiscal year of RI implementation, summarizing RI activities and significant findings.

WBS 201700: LAB AND BENCH-SCALE STUDIES

To evaluate remedial action alternatives, bench and pilot studies may be necessary. The exact studies that may be conducted have not been determined. An assessment of data collected during the RI will lead to the identification of specific studies during preparation of the RI Report. Potential studies may include treatability tests such as groundwater treatment; solidification studies for impoundment and tank sludges and sediments; and studies on in-tank solidification of sludges.

2.5 PRELIMINARY SCHEDULE

The schedule (Figure 2-8) for implementing the activities specified in the RI Plan will be negotiated with EPA and TDHE as a part of the Federal Facilities Agreement. Completion of the RI

SCHEDULE TO BE NEGOTIATED AS PART OF THE FEDERAL FACILITIES AGREEMENT depends on funding availability and decisions affecting prioritization.

2.6 WAG 1 DATA BASE MANAGEMENT

The management of data during the WAG 1 RI will follow the guidance set forth in the project Data Base Management Plan (BNI, 1987d).

Data for WAG 1 will be collected through field and analytical sampling, reduction, validation, and reporting activities. Data requirements and specific sampling activities are presented in the FSP, which also identifies sampling frequencies, analyses protocols, equipment, and procedures. RI/FS Project Procedures 1601, 1602, and 1610 set specific sampling, analytical, and well installation protocols to be used during field data collection. The project QAP and related project procedures set the guidelines for chain of custody, field quality control, laboratory quality control, quality action, and QAAs. The protocols for WAG 1 are summarized in the QAPP, Appendix A.

Collected data will be transferred to the WAG 1 data base by electronic data transfer or by standard data transmittal forms (as described in Project Procedures 1501 and 1501.1). The data transferred via standard collection forms will be entered twice by different personnel to ensure data accuracy. Preliminary checks for errors will be performed on raw data before acceptance into the data base.

The Data Base Coordinator will conduct verification/analysis of the raw data. Accepted data will undergo review by the technical specialists for WAG 1. Data that pass the review shall be considered verified/validated data. Rejected data will be further evaluated for possible limited use or purging. The verified/validated data will be analyzed using the methods presented in Section 5.0.

2.7 WAG 1 ENVIRONMENTAL, SAFETY AND HEALTH PLAN

The RI/FS project ES&H Plan has been finalized and establishes the overall organization, interfaces, criteria, and guidance for ensuring that RI/FS project activities comply with federal, state, DOE, ORNL, and Energy Systems laws, regulations, orders, requirements, and procedures (BNI, 1987b). A WAG-1-specific ES&H Plan that meets the requirements specified in OSHA 29 CFR 1910.120 will be prepared for discrete elements of work at the site. At that time, the ES&H implications of the field work to be performed will be evaluated; the BNI Team will then develop specific ES&H guidance directly applicable to the work.

3.0 DESCRIPTION OF CURRENT SITUATION

Section 3.1 provides general background information for the Oak Ridge Reservation (ORR). Sections 3.2 and 3.3 provide background information specifically for WAG 1.

3.1 BACKGROUND INFORMATION

3.1.1 Location

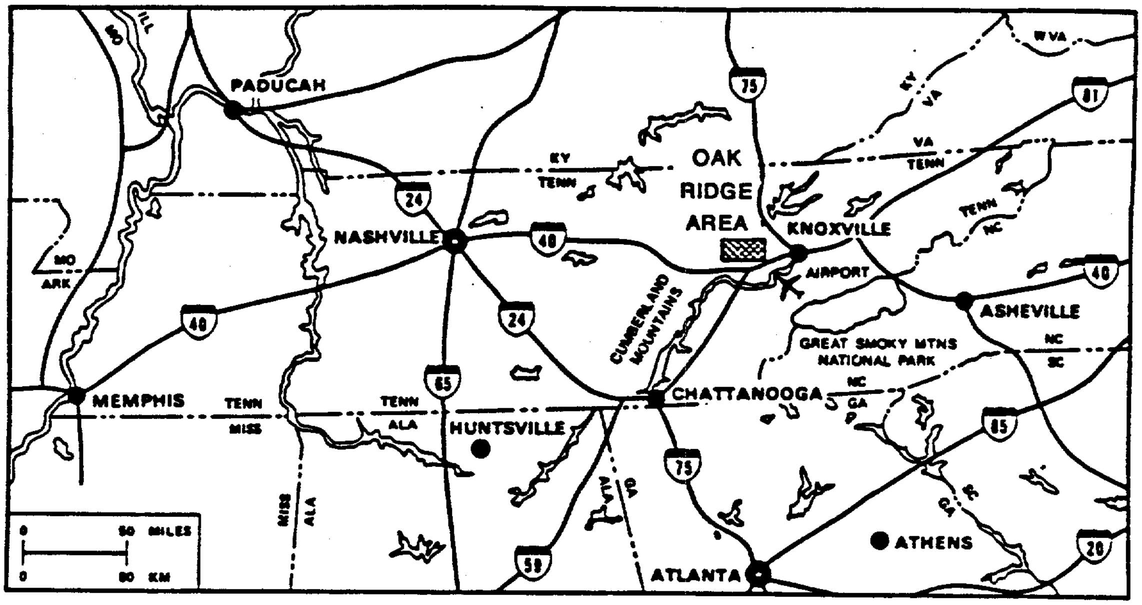
WAG 1 is located in the Main Plant Area of ORNL. ORNL is located near the center of the ORR in Roane and Anderson Counties in East Tennessee (Figure 3-1), approximately 30 miles southwest of Knoxville and 10 miles south of the City of Oak Ridge. ORNL is one of three major operating facilities on the ORR; the other two are the K-25 Oak Ridge Gaseous Diffusion Plant (ORGDP) and the Y-12 Plant.

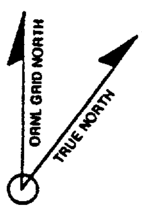
The ORR is bounded on the south and west by the Clinch River, on the east by State Highway 62, and on the north by the City of Oak Ridge and privately owned land. The ORR encompasses approximately 70 mi^2 of land.

3.1.2 Demography and Land Use

Surrounding the ORR are five counties with a combined population of approximately 480,000. Population centers close to the ORR include Oak Ridge and Knoxville with populations of 27,600 and 183,000, respectively. Other, smaller, population centers include Clinton (northeast), Kingston (southwest), and Harriman (west). The total population within a 50-mile radius of the ORR is about 690,000, with the largest percentage located to the east. Approximately 4150 people are employed at ORNL.

ORNL DWG 87-7844





ORNL DWG 87-7053

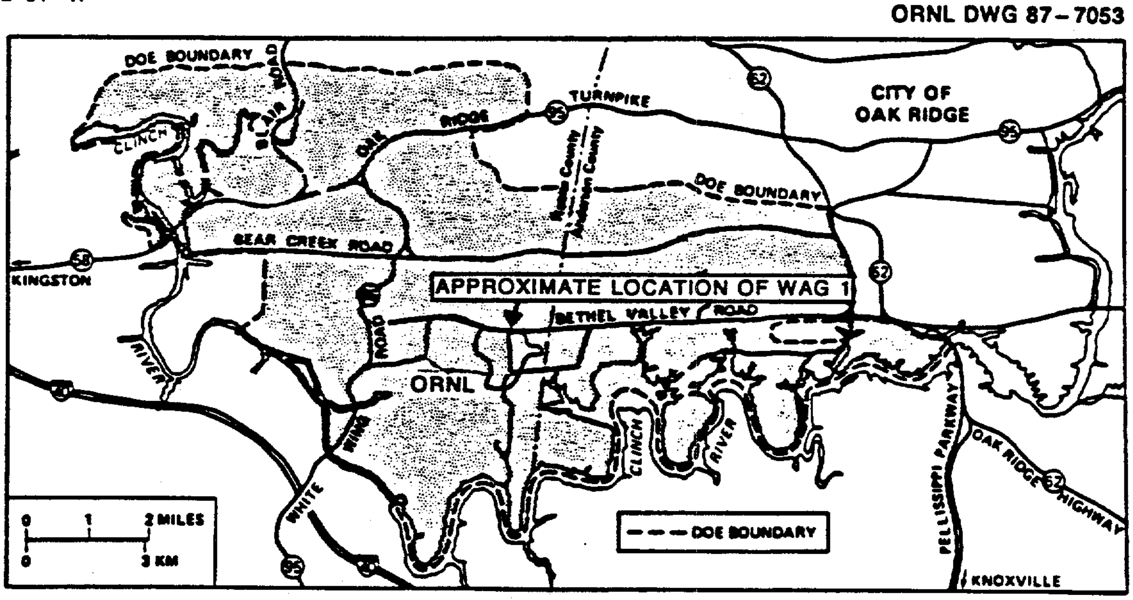


FIGURE 3-1
MAPS SHOWING LOCATIONS OF OAK RIDGE, TENNESSEE; THE DOE ORR; AND APPROXIMATE LOCATION OF WAG 1

Historically, the ORR area was used for agricultural purposes. Currently, the area outside the ORR includes residential, agricultural, industrial, and recreational areas. The region is also traversed by numerous public roads and highways. Recreational use of area rivers and lakes is heavy. Deer hunting has been allowed on the ORR in selected areas since 1985.

3.1.3 General History

ORNL was constructed for atomic weapons materials research and development during World War II and began operation in 1943. It was initially chosen for the Manhattan Project for security reasons, due to its isolation from population centers. The availability of inexpensive Tennessee Valley Authority (TVA) electric power, the abundant supply of good water, and the available labor force from the surrounding rural areas were also factors in locating the facility (Evaluation Research Corporation, 1982).

Initially the facility had a planned life of only one year. This period was lengthened to last for 2-3 years, and, as nuclear research and political climates have evolved, ORNL has been in continuous activity since.

After its war time mission was completed, the Manhattan Project was transferred from the Manhattan Engineering District in 1947 to the United States Atomic Energy Commission (USAEC), a civilian agency created to supervise the nation's nuclear energy program. ORNL, as part of the USAEC, was assigned chemical engineering and basic science program responsibilities in reactor and isotope research and development.

There have been many changes in the scope and direction of programs at ORNL over the years, including continuation and expansion of fuel reprocessing research, large-scale production of radioisotopes, and operation of a variety of reactors. Discharge of radioactive waste materials has resulted from many activities over the past 44 years.

When operations at ORNL began, the risks and waste management requirements of radiological science, work, and production were not well known. Furthermore, the long-term effects of exposure or contamination to humans and the environment were not well understood. Due to these factors, the methods of operation, protection, and waste disposal at ORNL have been evolving processes, and many of the standard waste disposal methods now followed did not exist during past operations. Past practices account for the majority of the environmental problems affecting the ORNL area.

The RI/FS Project Management Plan contains a thorough discussion of the history of ORNL and its waste disposal methods (BNI, 1987).

3.1.4 Current and Planned Site Operations

WAG 1 encompasses a large portion of ORNL's Main Plant Area, an active facility with a variety of ongoing activities. This fact will affect the WAG 1 RI in two ways.

First, the WAG 1 field activities will be conducted concurrently with other ORNL activities, which may include installation of new process waste pipelines, chemical or radiological characterizations, construction of major new facilities, or routine maintenance activities. These activities will present difficulties in that they may, for example, impact scheduling of certain WAG 1 field work or access to certain areas. However, such activities could just as well present opportunities for gaining information that would be useful to the WAG 1 RI effort, such as the location of underground utility lines or obtaining independent data on water quality. Through close interface with Energy Systems, the WAG 1 RI team can lessen the impact of possibly difficult situations and take full advantage of opportunities for obtaining useful data inexpensively and quickly.

Another significant impact of ongoing operations lies in the effect those operations may have on the configuration of WAG 1 over a period of years. New facilities may be added or other changes may be made that affect terrain, surface water flow, etc. These changes could affect the validity of data obtained or evaluations made during the RI; additional field work might be required to update information. Therefore, the possible effects of the changing configuration of WAG 1 will be closely monitored during the RI.

3.1.5 Physiography and Topography

The ORR is located between the Cumberland Mountains to the northwest and the Great Smoky Mountains to the southeast, in the Valley and Ridge Physiographic Province of the Appalachian Mountains. The province, which is some 50 miles wide in this area, extends approximately 1300 miles from the Canadian St. Lawrence low land into Alabama. Bounded by the Appalachian Plateaus Province to the west and the Blue Ridge Province to the east, the Valley and Ridge Province is a complex zone characterized by a succession of southwest-trending ridges and valleys. On the ORR, elevations range from 750 to 1400 ft mean sea level (MSL). The main facilities of ORNL, including WAG 1, are located in Bethel Valley at 800 to 850 ft MSL. Bethel Valley is bounded on the north by Chestnut Ridge (1100 ft MSL) and on the south by Haw Ridge (1000 ft MSL).

3.1.6 Regional Environmental Setting

3.1.6.1 Geology. The rocks that underlie the Valley and Ridge Province in the vicinity of the ORR are lower Paleozoic sediments. From oldest to youngest, the stratigraphic units that occur within the study area between Chestnut Ridge and Melton Valley are the clastic Cambrian Rome Formation, the mixed clastic and carbonate Cambrian Conasauga Group, the carbonate Cambrian and Ordovician Knox Group, and the mixed carbonate and clastic Middle Ordovician Chickamauga Group (Stockdale, 1951; McMaster, 1963). A generalized geologic cross section for the Oak Ridge area is provided in Figure 3-2. Figure 3-3 illustrates bedrock formations that are younger than the Chickamauga Group. Although present in the Oak Ridge area, these do not occur within WAG 1 and are therefore not included in this discussion.

The stratigraphic units crop out in a series of southwest- to northeast-trending linear belts that are the result of thrust fault motion along the Copper Creek and White Oak Mountain thrust faults. The thrust faulting is part of a major decollement of the Southern Appalachian thin-skinned orogenic thrust belt (Roeder, Gilbert, and Witherspoon, 1978). In the general vicinity of the ORR, such faulting has resulted in the Cambrian Rome Formation being juxtaposed over the Ordovician Chickamauga Group. Regional strike of strata in this portion of the Valley and Ridge Province is N50° to 60°E, and the dip of rocks at the surface is 45° to 55° to the southeast. At depth, the dip decreases to nearly horizontal, and the thrust faults become nearly horizontal in the subsurface to form essentially bedding-parallel faults. Horizontal displacement along major faults can be as great as 30 to 60 miles (Roeder, Gilbert, and Witherspoon, 1978). Within the sediments of the imbricate thrust sheets, a large number of small scale folds and fractures have formed, which has resulted in a complex structural fabric.

3.1.6.2 Seismic Activity. A complete list of recent seismic events detected in the Oak Ridge area and those recorded in the literature since 1800 is found in Boyle (1982). The Appalachian region from southeastern Tennessee to Virginia averages one to two seismic events per year. The maximum shock experienced in the Oak Ridge area from an earthquake with an epicenter in the East Tennessee region was an MM (Modified Mercalli) VI intensity event in 1913.

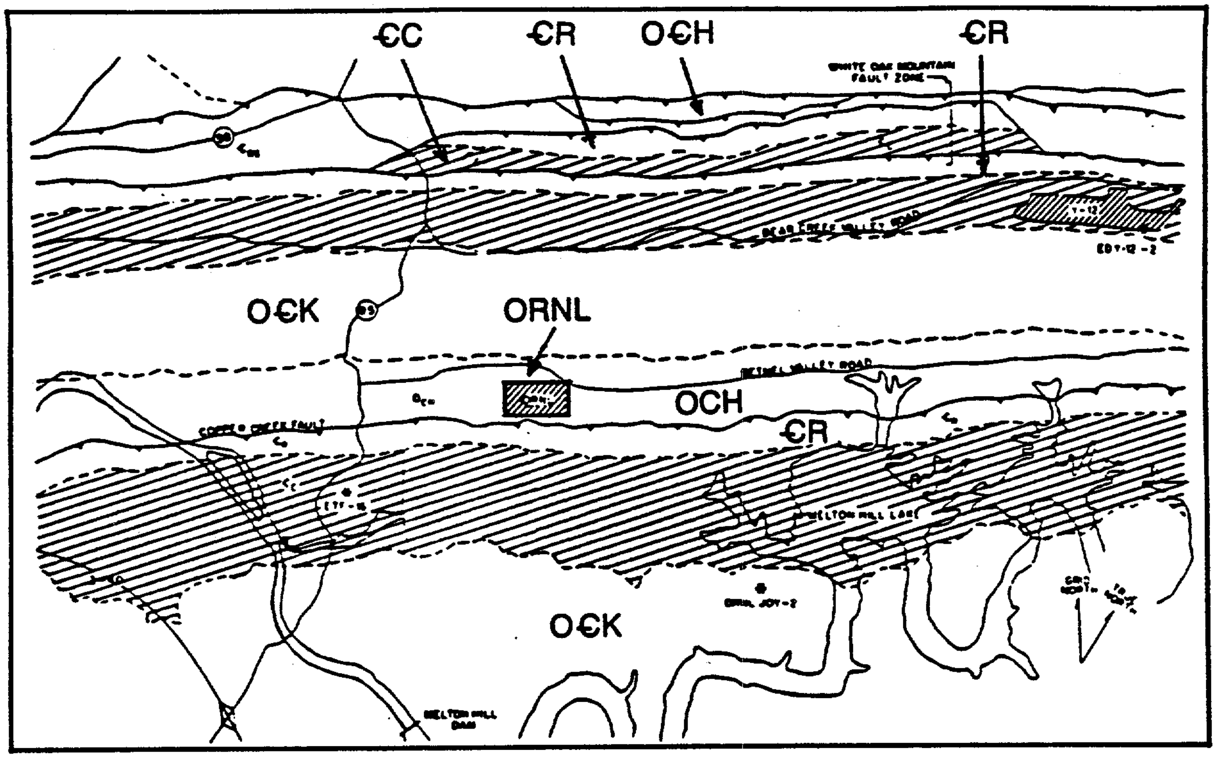
Based on Algermissen's (1982) seismic risk classification and probabilistic estimates, Oak Ridge lies in seismic zone 2 (moderate

System	Group	Formation	"Member" or Unit	Thickness (feet)	Characteristics of Rocks
Mississippian		Ft. Payne "chart"			Impure limestone and calcareous siltstone, with much chert
	?	Chattanooga shale			Shale, black, fissile
Devonian					
Silurian					
	Rockwood group	Brassfield		1000+	Shale, sandy shale, sandstone; calcareous; red, drab, brown
		Sequatchie			
			?		
Ordovician	Chickamauga group		H	300+	Limestone, shaly limestone, calcareous siltstone, and shale; mostly gray, partly maroon; with cherty zones in basal portions
			G	300	
			F	25	
			E	380	
			D	160	
			C	115	
			B	215	
			A	240	
	Knox group			2600	Dolomitic limestone; light to dark gray; with prominent chert zones
Cambrian	Conasauga group	Maynardville limestone		1500	Shale; gray, olive, drab, brown; with beds of limestone in upper part
		Conasauga shale	Pumpkin valley		
		Rome formation		1000+	Sandstone and shale; variegated with brilliant yellow, brown, red, maroon, olive-green; with dolomitic limestone lenses

SOURCE: ORNL/RAP-13 BOEGLY et al. (1987)

FIGURE 3-2
GENERALIZED GEOLOGIC CROSS-SECTION OF THE BEDROCK FORMATIONS IN THE OAK RIDGE AREA

ORNL-DWG 83-12595R1



SOURCE: ORNL/RAP-7 (1987a)

O€	ORDIVICIAN CAMBRIAN
€	CAMBRIAN
CH	CHICAMAUGA GROUP
R	ROME FORMATION
C	CONASAUGA GROUP
- - - -	FORMATION CONTACT
—▼—	THRUST FAULT
K	KNOX GROUP

FIGURE 3-3
GENERALIZED GEOLOGIC MAP
OF THE OAK RIDGE RESERVATION

activity), and there is a 10 percent probability that a seismic event will produce horizontal movement at Oak Ridge in excess of 7 percent of gravity within a 50-year period. This corresponds to an MM intensity of VII. This estimate and historic records indicate that an earthquake of this intensity, which would cause minor to moderate damage to structures, should occur every 300 to 1000 years.

Although the Oak Ridge area experiences a moderate level of seismic activity, no incidence of recent surface deformation has been documented. Earthquakes of the type that occur within the region are common throughout the world. The shocks are of normal focus, that is, 25 to 30 miles deep. It is improbable that a shock of major intensity will occur in the Oak Ridge area for several thousand years. Forces from more seismically active areas would be dissipated by distance.

3.1.6.3 <u>Soils</u>. The soils occurring in the ORR vicinity belong generally to the broad group of ultisols, formerly called red-yellow podzolic and reddish brown lateritic soils. Entisols (formerly lithosols), thin surface soils over bedrock showing little development of soil horizons, are found locally in steeply sloping areas. Small areas of inceptisols or youthful soils are found in alluvial areas adjacent to streams.

Ultisols develop in humid climates of temperate to tropical zones on old or highly weathered parent material under forest or savannah vegetation. Although soils on the ORR exhibit a wide range of both physical and chemical properties, they are generally moist, strongly leached, acidic, low in organic matter, and have exchange capacities less than 10 meq per 0.22 lb of soil.

The geochemical and mineralogical properties of a soil depend to a large degree on the source material from which they are derived. Generally, native soils can be classified as residuum, colluvium, or alluvium, based on their location and type of weathering of source rock that produced those soils. The three known stratigraphic units from which site soils would be derived are the Rome Formation, the

Knox Group, and the eight units of the Chickamauga Group. Soils that directly underlie SWMUs within WAG 1 would primarily be weathering products of the rock of the Chickamauga Group. Boegly et al. (1987) describe these soils as follows.

The soils produced by weathering of the Chickamauga typically consist of yellow, light reddish-orange, or red clay containing variable amounts of chert. The residual clays produced by the weathering of the limestone contain a mixture of kaolinitic and illilitic minerals, with some clays having significant amounts of montmorillonitic minerals. At many locations on-site, these soils have been reworked or other soil has been brought in as backfill, thus altering some of the soils' native properties. The two principal clay series found beneath ORNL are the Gladeville and Collegedale. The only geochemical properties that have been determined for soils at ORNL are pH and cation exchange capacity (CEC) for these two series (Boegly et al., 1987). These properties are summarized in Table 3-1.

3.1.6.4 Surface Water. The facilities on the ORR discharge water principally to the Clinch River system. Four TVA reservoirs influence the flow and stage of the lower Clinch River: Norris and Melton Hill reservoirs on the Clinch River, and Watts Bar and Fort Loudon reservoirs on the Tennessee River, into which the Clinch flows some 15 miles below ORNL. The average discharge of the Clinch River at Melton Hill Dam, on the south side of the ORR, between 1963 and 1969, was 5280 cfs, and the maximum reported discharge is 42,900 cfs (Martin Marietta Energy Systems, 1986). Surface waters of the ORR are classified by use on the basis of water quality. Most waters are classified for fish and aquatic life, recreation, irrigation, and livestock watering and wildlife. The Clinch River is also classified for domestic and industrial water supplies and for navigation.

The surface waters of the ORR are of the calcium-magnesium bicarbonate type, reflecting the abundance of limestone and dolomite bedrock in the watersheds. These waters have a moderate hardness

TABLE 3-1

SOIL CHEMICAL PROPERTIES

	Corrosivity		pH range	Estimated CEC, (meq/100 g)	
	Steel	Concrete		Surface	Subsoil
Gladeville	High	Low	6.6-8.2	20-40	40-80
Collegedale	High	Mod-high	4.5-5.5	10-15	20-40

Source: Boegly et al. (1987).

and total dissolved solids (TDS) typically ranging from 100 to 250 mg/L. Seasonal variations in rainfall can produce large streamflows, typically in winter and spring.

Water quality in ORR streams is affected by wastewater discharges and by groundwater inputs of contaminants from shallow-land disposal of wastes. Bedrock characteristics differ somewhat among the watersheds, and some observed differences in water chemistry can be attributed to geological variation; variations in contaminant loading are also factors. Essentially all water used on the ORR is imported from the Clinch River, and any water not consumed is discharged to surface streams. Imported water is a significant fraction of the flow in some streams, e.g., WOC, in late summer and early fall. The quality of water in the Clinch River is affected by ORR activities, by contamination introduced upstream, and by flow regulation at TVA dams. Several institutions routinely monitor water quality in the Clinch River, including TVA, the U. S. Geological Survey (USGS), and Energy Systems for DOE (Martin Marietta Energy Systems, 1986).

3.1.6.5 Groundwater. There are limited data describing regional groundwater flow. Mechanisms and rates of flow appear to be controlled by topography, structure, and lithology. Because the lithologic nature of the Conasauga Group is highly variable, groundwater conditions also vary. In the carbonate-rich formations, groundwater may move along small solution cavities and fractures; in the more shale-rich lithologies, movement is almost solely along fractures and bedding planes.

The Knox Group is the principal aquifer in the region. It outcrops at Chestnut Ridge north of ORNL and at Copper Ridge south of ORNL. The Knox Group is characterized by extensive solution features, and most groundwater flow in the bedrock is along solution cavities. Because the Knox is a ridge-former and has a thick residual cover of 75 to 150 ft, depth to the water table is often as great as 100 ft.

The groundwater flow conditions of the Chickamauga Group are highly variable and not well defined. Groundwater conditions appear to be controlled by topography, structure, and lithology, and small solution cavities occur in the more carbonate-rich strata.

A predominant feature of groundwater flow at the ORR and the surrounding region is that most flowpaths are determined by directional permeabilities in bedrock fractures. Porous flow occurs only in the regolith above the bedrock surface. In general, shallow groundwater from the Conasauga, Knox, and Chickamauga groups is fresh and can be used for residential purposes. Water deeper than about 300 ft is saline to very saline.

3.1.6.6 Background Radiological Status. A natural background radiation dose is received by man from cosmic rays and terrestrial sources. The estimated average annual dose equivalent to individuals in the Oak Ridge area from these natural sources is about 1.3 mSv/yr (Myrick, 1984). Man-made radiation sources include residual fallout from nuclear weapons testing, routine nuclear power plant operation, medical uses of radiation, air travel, technologically enhanced radiation, and certain consumer products. The annual dose equivalent to a typical U. S. resident from man-made sources is estimated at approximately 1.0 mSv/yr (Myrick, 1984).

Residents in the Oak Ridge area are also exposed to routine releases from the DOE facilities on the ORR. The 50-year dose equivalent commitment to the total body of the hypothetical maximally exposed individual from releases from the ORR has been estimated to be approximately 0.06 mSv (Myrick, 1984).

3.1.6.7 Climate. Prevailing winds in the area are usually either up-valley, from west to southwest, or down-valley, from east to northeast. Daytime winds are usually southwesterly; nighttime winds are usually northeasterly (Figure 3-4). The mountains cause a

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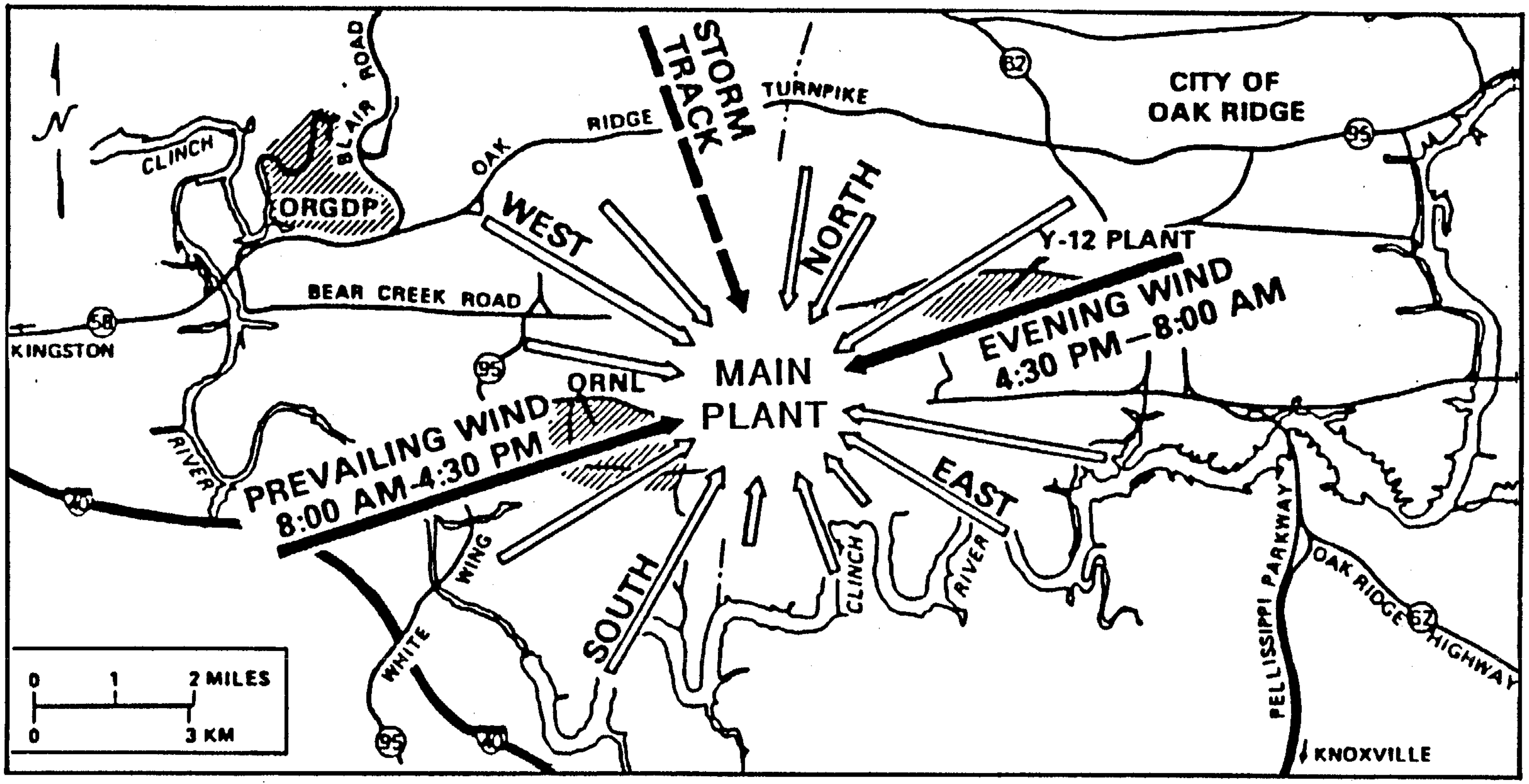

SOURCE: OAKES et al., 1987

FIGURE 3-4
ALL-SEASON WIND DIRECTION DIAGRAM DEPICTING ANNUAL PREVAILING WINDS

C23/wag1-9

decrease in wind velocities, so tornadoes rarely occur in the valley (NOAA, 1982). Table 3-2 shows the monthly average wind speed, direction, and maximum velocity for the Oak Ridge Station (NOAA, 1982).

Recorded mean, maximum, and minimum temperatures at Oak Ridge for the period 1965 through 1986 are given in Table 3-3. The coldest month is normally January, but differences between the mean temperatures of December, January, and February are comparatively small. July is usually the hottest month, although differences in mean temperature for June, July, and August are small. The average daily temperature range is 54°F, with the greatest average range in spring and fall and the smallest in winter. Temperatures seldom rise above 100°F or drop below 0°F. Mean annual precipitation, as measured at the Oak Ridge Meteorological Station, is 55 in. (Table 3-4) (NOAA, 1982). Precipitation for 1986 was 38.8 in., about 16 in. short of the annual average (Oakes et al., 1987).

3.1.6.8 Biota. The following subsections provide basic information about the biota in the area of the ORR.

Flora

The environs of WAG 1 are typical of the ecological systems of the Appalachian region. The dominant plant community is the Old Hickory Forest, with extensive stands of mixed yellow pine and hardwoods. Nonforest areas include grasslands, devegetated areas, and developed locations. Nonforest areas predominate in WAG 1.

Fauna

The forests in the ORR serve as host for many forest wildlife species. Thus the area may serve as a refuge for wildlife (de Laguna et al., 1958). Approximately 60 species of reptiles and

TABLE 3-2

WIND RECORDS FOR OAK RIDGE, TENNESSEE

Month	Mean Wind Speed[a] (mph)	Prevailing Direction[b]	Peak Wind Speed (gust)[c] (mph)
January	3.4	SW	42
February	3.2	ENE	34
March	3.9	SW	34
April	4.0	SW	35
May	3.2	SW	34
June	3.1	SW	35
July	2.7	SW	35
August	2.7	E	39
September	2.7	E	27
October	2.6	E	27
November	2.9	E	32
December	3.2	SW	35
Annual	3.2	SW	42

[a]Sixteen-year record through 1964.
[b]Thirteen-year record.
[c]Twenty-two-year record through September 1979.

Source: NOAA (1982).

TABLE 3-3

MONTHLY TEMPERATURE SUMMARY FOR THE OAK RIDGE AREA BASED ON A 20-YEAR PERIOD

Month	Temperature Max °C[b]	Temperature Min °C	Temperature Mean °C
January	9.3	-1.8	3.3
February	10.7	-0.8	4.9
March	14.8	2.4	8.6
April	21.7	8.3	15.0
May	26.2	12.5	19.3
June	29.6	17.1	23.3
July	30.7	19.1	24.9
August	30.4	18.4	24.4
September	27.5	14.8	21.2
October	21.8	8.4	15.2
November	14.3	2.2	8.3
December	9.3	-0.8	4.3
Annual			14.4

Source: NOAA (1965-1986).

TABLE 3-4

MONTHLY PRECIPITATION RECORD FOR OAK RIDGE METEOROLOGICAL STATION (1947-1980)

Month	Monthly Mean (in.)	Monthly Mean (cm)
January	5.54	14.07
February	4.75	12.06
March	6.13	15.57
April	4.28	10.87
May	4.24	10.77
June	4.12	10.46
July	5.41	13.74
August	3.81	9.68
September	3.62	9.19
October	2.89	7.34
November	4.61	11.71
December	5.60	14.22
TOTAL ANNUAL	55.00	139.70

Source: NOAA (1982).

amphibians; more than 120 species of terrestrial birds; 32 species of waterfowl, wading birds, and shore birds; and about 40 species of mammals have been recorded (Nix et al., 1986).

Rare, Threatened, or Endangered Species

The plant species in the ORR area that are considered by the state of Tennessee to be endangered or threatened are listed in Table 3-5, and their locations are shown in Figure 3-5. There are no known species that are included in the federal list of threatened or endangered plants, although three area species--false foxglove (Aureolaria patula), bugbane (Amicifuga rubifolia), and Carey's saxifrage (Saxifrage careyana)--have been proposed for inclusion on the list (Davis et al., 1984). WAG 1 is not known to have any threatened or endangered plant species.

Twelve animal species on the federal endangered species list have geographic ranges that fall within the ORR (Myrick, 1984). Only two species, the southern bald eagle (Haliaeetus lencocephalus) and the eastern couger (Felis coucolor cougar), have been sighted on the reservation. Eagles have been sighted in both winter and summer, but none are known to nest in the area. Though numerous sightings of cougars have been reported during the last decade, a search for cougars by the U.S. Fish and Wildlife Service has failed to show conclusive evidence of a cougar population.

Aquatic

The aquatic communities potentially affected by WAG 1 include the WOC Watershed and the Clinch River downstream from the mouth of WOC. This portion of the WOC basin will be considered in the WAG 2 RI. Table 3-6 summarizes aquatic biota in the WOC basin found north and south of ORNL. The WOC Watershed is not known to have any threatened or endangered species.

TABLE 3-5

RARE PLANT SPECIES ON THE OAK RIDGE RESERVATION

Genus Species	Family	Common Name	Status on State List[a]
Aureolaria patula	Scrophulariaceae	False foxglove	T
Cimicifuga rubifolia	Ranunculaceae	Bugbane	T
Delphinium exaltatum	Ranunculaceae	Tall larkspur	E
Fothergilla major	Hamamelidaceae	Witch alder	T
Hydrastis canadensis	Ranunculaceae	Goldenseal	T
Liatris cylindracea	Asteraceae	Blazing star	E
Lilium canadense	Liliaceae	Canada lily	T
Panax quinquefolius	Araliaceae	Ginseng	T
Saxifraga careyana	Saxifragaceae	Carey's saxifrage	S
Solidago ptarmicoides	Asteraceae	Goldenrod	T
Spiranthes ovalis	Orchidaceae	Lesser ladies' tresses	S
Tomanthera auriculata	Scrophulariaceae	Auricled gerardia	E

[a] Status as listed on the official List of Tennessee's Rare Plants:

E = Endangered - Species now in danger of becoming extinct in Tennessee because of their rarity throughout their range or their rarity in Tennessee as a result of sensitive habitat or restricted area of distribution.

T = Threatened - Species likely to become endangered in the immediately foreseeable future as a result of rapid habitat destruction or commercial exploitation.

S = Special concern - Species requiring particular attention because they are rare or distinctive in Tennessee because the state represents the limit or near-limit of their geographic range or their status is undetermined because of insufficient information.

Source: Davis et al. (1984).

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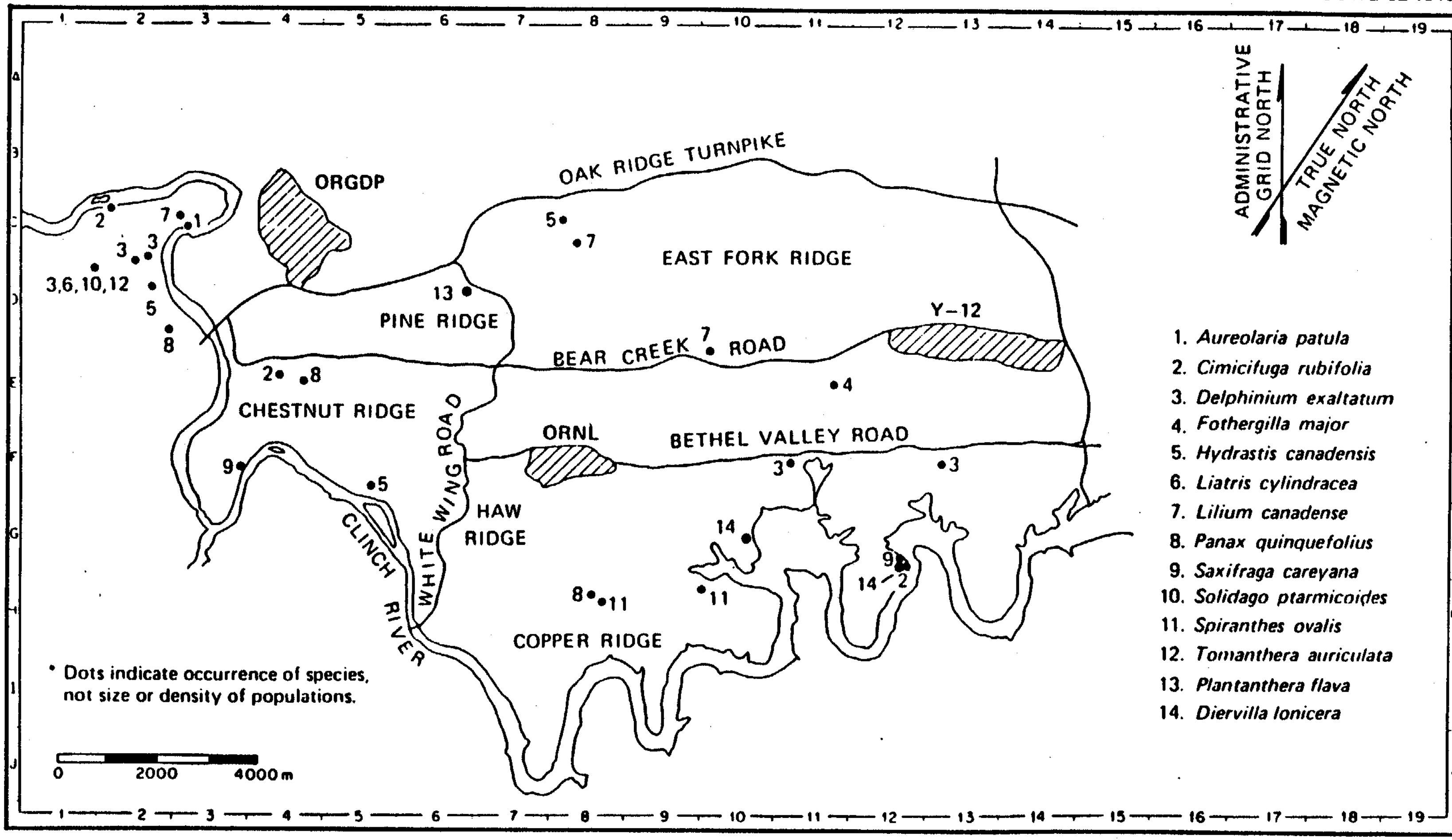

SOURCE: DAVIS et al. (1984)

FIGURE 3-5
ENDANGERED AND THREATENED PLANT SPECIES KNOWN TO OCCUR ON THE OAK RIDGE RESERVATION

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TABLE 3-6

NUMBER OF TAXA AND DOMINANT GROUP IN WHITE OAK BASIN ABOVE AND BELOW ORNL

Taxa	White Oak Creek North of ORNL	White Oak Creek South of ORNL
Periphyton	21 Achnanthes (37%)	27 Achnanthes
Benthic macroinvertebrates	44 Mayfly larvae (41%)	14 Midge larvae (98%)
Fish	3 Stone roller (57%)	None

Source: Loar et al. (1981).

Monitoring

Routine biological monitoring on the ORR involves fish, milk, waterfowl, deer, and vegetative sampling. For a recent analysis, fish were sampled semiannually from three Clinch River locations for tissue analysis of radionuclides, mercury, and polychlorinated biphenyls (PCBs). Mercury and PCBs were below the Food and Drug Administration (FDA) action level (Oakes et al., 1987). The results of the analysis are presented in Table 3-7.

Milk sampling was conducted at six locations in the Oak Ridge area every two weeks and at remote sampling stations semiannually. These samples were less than 2.5 percent of the Federal Regulatory Commission (FRC) guidelines for milk consumption.

Waterfowl sampling consisted of four geese residing near pond 3524 and random samples of geese from the ORGDP and the Y-12 plant. As shown in Table 3-8, tests showed less-than-detectable amounts of human-made radionuclides except strontium-90 (Oakes et al., 1987). These studies indicate a possibility for radionuclide transport by migratory waterfowl.

Five weekend hunts for deer on the ORR and contiguous lands during the fall of 1986 harvested 660 deer, and these were used for testing for cesium-137 and strontium-90. Soft-tissue radionuclide concentrations were low and acceptable for the entire harvest. Only 4.4 percent of the deer had levels of 30 pCi/g or greater of strontium-90 in bone, which was the retention level. The retention level was set to limit the dose to the hunter to 25 mrem if he consumed 100 kg of meat.

TABLE 3-7

AVERAGE SAMPLING RESULTS OF FISH FOR RADIONUCLIDES

Sampling Location	^{60}Co pCi/kg Net Weight	^{137}Cs pCi/kg Net Weight	^{90}Sr pCi/kg Net Weight
Above all Oak Ridge installations' outfalls	<4.3	<4.8	5.9
ORNL's discharge point from White Oak Creek to the Clinch River	<13	410	29
Downstream from Oak Ridge Y-12	<7.8	77	16

1 Bq = 27.03 pCi

Source: Oakes et al. (1987).

TABLE 3-8

AVERAGE STRONTIUM-90 CONCENTRATION IN THE MUSCLE AND BONE OF CANADA GEESE

	Concentration (pCi/g)	
	Pond 3524	Oak Ridge Reservation
Muscle	1.8	0.2
Bone	750	0.6

1 Bq = 27.03 pCi

Source: Oakes et al. (1987).

3.1.7 Site Security

The existing Main Plant area security program provides restricted site access in accordance with DOE Orders 5480.2 (Hazardous and Radioactive Mixed Waste Management, Chapter I - General Hazardous Waste Program Requirements), and 5820.2 (Radioactive Waste Management, Chapter 3 - Management of Low-Level Waste), and ORNL procedures. In the interest of security and safety, entry of unauthorized personnel is prohibited. The ORNL complex is under continuous (24-hour, 7-day-per-week) control of armed guards from the ORNL Guard Department. The Main Plant Area, including WAG 1 with the exceptions of SWMU 1 and SWMU 1.18, is within the confines of the ORNL complex and is afforded additional security by its location within a heavily forested, government-owned reservation.

3.1.8 Regulatory Summary

The regulatory framework that applies to the WAG 1 RI is derived from three federal statutes. These statutes and their applicability to the RI/FS project and the activities at WAG 1 are as follows:

- National Environmental Policy Act (NEPA) requirements are applicable to "major federal actions significantly affecting the quality of the human environment."
- The Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), including the Superfund Amendments and Reauthorization Act of 1986 (SARA), specifically require that, where appropriate, each facility on the Federal Agency Hazardous Waste Compliance docket perform an evaluation in accordance with the criteria established in accordance with Section 105 of CERCLA under the National Contingency Plan (NCP) for determining priorities among releases.
- The Resource Conservation and Recovery Act, including the Hazardous and Solid Waste Amendments (HSWA) of 1984, regulates the owners and operators of facilities that treat, store, or dispose of hazardous waste.

In addition, DOE Order 5480.1 lays out a remedial action activities process that is heavily modeled on CERCLA's NCP.

RCRA is the statute most clearly applicable to the RI/FS project and WAG 1 activities, because its provisions are being used by EPA in enforcement actions at ORNL. This includes RCRA Section 3004(u), which requires corrective action for releases to all media and all units at a RCRA facility, regardless of when they were used or whether they are covered by an RCRA permit.

EPA's definition of a unit is applicable to the ORNL SWMUs. This definition is as follows:

> ". . . any discernable waste management unit at an RCRA facility from which hazardous constituents might migrate, irrespective of whether the unit was intended for the management of solid and/or hazardous waste. This definition includes containers, tanks, surface impoundments, waste piles, land treatment units, landfills, incinerators, and underground injection wells, including those units defined as 'regulated units' under RCRA. Also included are recycling units, wastewater treatment units, and other units which EPA has generally exempted from standards applicable to hazardous waste management units, and areas contaminated by 'routine, systematic, and deliberate discharges' from process areas" (EPA, 1986).

The definition does not include accidental spills from production areas and units (e.g., product storage areas) in which wastes have not been managed (EPA, 1986).

As the first step in identifying compliance requirements under RCRA Section 3004(u) for ORNL, a list of all known active and inactive waste management units, contaminated facilities, and other potential sources of continuing releases to the environment was prepared. Included in this list for WAG 1 were waste collection and storage tanks, SWSAs, waste treatment units, impoundments, spill sites, pipeline leak sites, and areas of known contamination within buildings. Although some of the identified sites might not be regulated under RCRA Section 3004(u), they were included in the site listing to maintain a comprehensive inventory of all sites that might require some form of remedial action. The listing compiled for WAG 1 currently includes 99 SWMUs and 16 non-SWMUs that might be considered for remedial action (ORNL, 1987a).

Due to the long and complex history of operations at ORNL, identification and listing of SWMUs is an ongoing process. Throughout ORNL and with WAG 1, there are without doubt other as-yet-unidentified SWMUs. During the WAG 1 RI, additional review of historical records and interviews of knowledgeable personnel will be conducted to guide field investigations that may identify other SWMUs. However, for the purposes of this RI Plan, only the currently identified 99 SWMUs have been considered.

3.2 NATURE AND EXTENT OF CONTAMINATION

ORNL has prepared a list of known active and inactive waste management units, contaminated facilities, and other potential sources of continuing releases to the environment. Included in this list are waste collection and storage tanks, SWSAs, waste treatment units, impoundments, spill sites, pipeline leak sites, and areas of known contamination within buildings. Because of the complex hydrogeology of ORNL and the large number of sites involved (250), the ORNL sites have been grouped into 20 geographically contiguous and hydrologically defined WAGs.

Initially, WAG 1 contained 99 SWMUs. After submittal of the WAG 1 RI Plan, an addendum to the RCRA Facility Assessment for ORNL (ORNL, 1987) was issued identifying 21 additional SWMUs. Of these 21 additional SWMUs, 16 were subsequently deleted from consideration as a result of the January 1989 SWMU update listing that was submitted to DOE by ORNL (Rohwer, 1989). Concomitantly, 12 of the original 99 SWMUs were also removed from consideration by this same update. Those SWMUs removed from consideration are listed in Table 3-8a. At present, there are 92 SWMUs contained in WAG 1 (Figure 3-6), and a listing of these SWMUs by type can be found in Table 3-9. Five of these were not described in the original WAG 1 RI Plan and are discussed below.

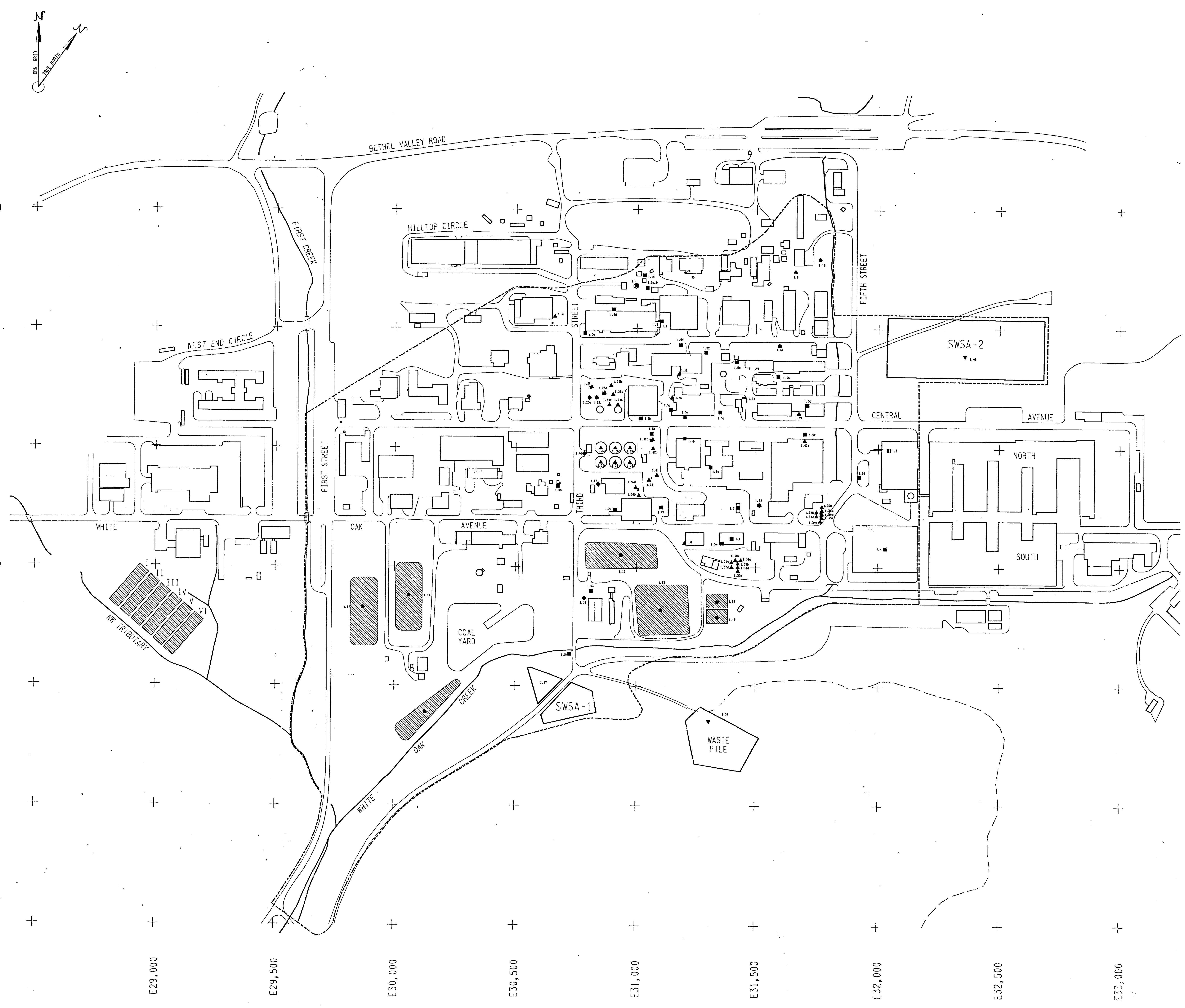
Radiological wastes identified at ORNL contain a variety of known or suspected radionuclides. From a review of documents (Huang et al., 1984b; ORNL 1987b; Oakes et al., 1987; and Peretz el al., 1986), the following radionuclides have been identified:

TABLE 3-8a

ORNL RCRA/CERCLA UNITS IN WAG 1 LISTED AS REQUIRING NO FURTHER ACTION AND REMOVED FROM CONSIDERATION IN THE WAG 1 RI

SWMU Number	Title
1.18	Coal Pile Settling Basin (2545)
1.43a	Active LLW Waste Collection/Storage Tank W-21
1.43b	Active LLW Waste Collection/Storage Tank W-22
1.44	Active LLW Waste Concentrate Tank W-23
1.45a	Active LLW Waste Concentrate Tank C-1
1.45b	Active LLW Waste Concentrate Tank C-2
1.48	Low-Level Waste Evaporator 2531
1.49	Neutralization Facility 3518
1.50	PCB Storage Area 2018N
1.51	Process Waste Treatment Plant 3544
1.52	Sewage Treatment Plant 2521
1.53	Septic Tank for Building 3000 (3078)
1.55	Septic Tank for Building 5505 (5507)
1.57	Site Nonradiological Wastewater Treatment Plant
1.59	Old Incinerator Site
1.60	Site of Building of Efficiency and Renewable Energy Research
1.61a	Waste Accumulation Area 1503
1.61b	Oil Storage Area 2013
1.61c	Waste Oil Storage Area 2018
1.61d	Fluorescent Tube Container Storage Area 3025
1.61e	Waste Oil Storage Area 3038
1.61f	Oil Storage Area 3103
1.61g	Hazardous Waste Accumulation Area 3500
1.61h	Waste Oil Storage Area 3550
1.61i	Oil Storage Area 4500N
1.61j	Oil Storage Area 4500S
1.61k	Waste Oil Storage Area 4509
1.61l	PCB Waste Container Storage 6000

Source: Rohwer (1989).



NOTES

LEGEND

	BUILDING
	PAVED ROADS
	GRAVEL ROADS
	FENCE
	STREAM
	BASIN/POND
ѡ	MARSHY AREA
	WAG 1 BOUNDARY

SOLID WASTE MANAGEMENT UNITS

▲	COLLECTION & STORAGE TANK
▼	LAND DISPOSAL FACILITY
◆	WASTE TREATMENT FACILITY
■	LEAK OR OIL SPILL
●	BASIN/POND
1.3	SWMU NUMBER

FIGURE 3-6
WAG 1 SITE MAP

3-29

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TABLE 3-9

LISTING OF SWMUs BY TYPE

Solid Waste Management Units	Number of SWMUs
Collection and Storage Tanks (LLW)	
Inactive	25
Active	20
Leak/Spill Sites and Mercury Contaminated Soils	
Radioactive	30
Mercury	4
Ponds and Impoundments	
Radioactive Waste	6
Chemical Waste	2
Waste Treatment Facilities	
Radioactive Waste	2
Solid Waste Storage Areas	
Radioactive Waste	2
Chemical Waste	1
Total Number of WAG 1 SWMUs	92

Source: Boegly et al. (1987) and Rohwer (1989).

tritium	barium-140
carbon-14	cerium-141
sodium-24	cerium-144
calcium-45	promethium-147
chromium-51	europium-152
iron-55	europium-154
iron-59	europium-155
cobalt-60	mercury-203
nickel-63	radium-226
rubidium-86	thorium-232
zinc-65	thorium-234
strontium-89	uranium-232
strontium-90	uranium-233
zirconium-95	uranium-235
niobium-95	uranium-238
technetium-95m	neptunium-237
technetium-99	plutonium-238
ruthenium-106	plutonium-239
cadmium-115	plutonium-240
iodine-131	americium-241
cesium-134	curium-242
cesium-137	curium-244

Information concerning hazardous chemical contaminants is fragmentary and incomplete. However, a review of various documents (Boegly et al., 1987; Francis and Stansfield, 1986;) has indicated the presence of the following chemicals:

<u>Volatiles</u>

Carbon Tetrachloride
Chlorodibromomethane
Chloroform
Dichlorobromomethane
1,1-Dichloroethylene
Methylene Chloride
1,1,2,2-Tetrachloroethane
Tetrachloroethylene
Toluene
1,2-Trans-Dichloroethylene

<u>Base/Neutrals</u>

Anthracene
Benzo(A)Anthracene
Benzo(A)Pyrene
Benzo(B)Flouranthene
Chrysene
Di-N-Butyl Phthalate
Flouranthene
Indeno(1,2,3-CD) Pyrene
Phenanthrene
Pyrene

<u>Metals</u>

Aluminum
Arsenic
Barium
Beryllium
Cadmium
Chromium
Copper
Iron
Manganese
Molybdenum
Nickel
Lead
Mercury
Silver
Vanadium
Zinc
Potassium

<u>Pesticides</u>

Endrin

<u>Polychlorinated Biphenyls</u>

3.2.1 Waste Collection and Storage Tanks

Since operations at ORNL were initiated, 46 radioactive waste collection and storage tanks have been installed, with capacities ranging from 500 to 170,000 gal. The larger tanks originally were designed for long-term storage of wastes. However, as tank storage capacity became less available, ORNL began to treat wastes in the larger tanks and then dispose of the wastes.

In addition, buildings at ORNL that generated radioactive wastes were provided with waste collection tanks. Wastes were stored and sampled before a decision was made regarding disposition of the waste (i.e., storage in the main tanks or release to the process waste system for treatment before disposal).

Since ORNL operations began, a number of tanks have been removed from service because of leaks in either the tanks or the piping used to transfer wastes into or out of the tanks. In addition, some tanks are no longer in service because the programs they served have ceased operation. Of the existing tanks, 22 are now inactive; 24 active tanks continue to be used in support of waste management operations. The 22 inactive tanks still contain some liquid wastes and sludges and, in general, are contaminated with radionuclides and, possibly, hazardous chemicals.

More detailed information on the ORNL waste collection and storage tanks can be found in Huang et al. (1984a and 1984b), Taylor (1986), Horton (1984), Peretz et al. (1986), Binford and Orfi (1979), MCI (1985), and Coobs and Myrick (1983).

3.2.1.1 Active Tanks. Brief descriptions of each of the active tanks are provided below. The capacities and contents of these tanks are provided in Table 3-10.

TABLE 3-10

INVENTORIES OF MAJOR CONTAMINANTS AT THE MAIN PLANT AREA (WAG 1) SWMUs

SWMU Site[(a)]	Contaminant	Inventory[(b)] [Ci (kg)]	Current Contents		
			Volume (gal)	Sludge (gal)	Liquid (gal)
1.1 Contaminated Soil (3503)	Hg	(<1.0 est.)	Unknown	N/A	N/A
1.2 Contaminated Soil (3592)	Hg	($\leq$1.4 X 10^3)	Unknown	N/A	N/A
1.3 Contaminated Soil (4501)	Hg	(<10 est.)	Unknown	N/A	N/A
1.4 Contaminated Soil (4508)	Hg	Presence unconfirmed	Unknown	N/A	N/A
1.5 LLW Lines and Leak Sites					
1.5a Bldg 3020, South	LLW[(c)]	Unknown	Unknown	N/A	N/A
1.5b Bldg 3020, East	LLW	Unknown	Unknown	N/A	N/A
1.5c Bldg 3082, West	LLW	Unknown	Unknown	N/A	N/A
1.5d Bldg 3019, North	LLW	Unknown	Unknown	N/A	N/A
1.5e Bldg 3019, Southwest	Sr-90, Co-60, mixed fission products, alpha emitters	Unknown	Unknown	N/A	N/A
1.5f Bldg 3110, Between W-5 and WC-19	Cd-115, Ce-141, Ba-140, Nb-95	Unknown	Unknown	N/A	N/A
1.5g Bldg 3047, Underneath	LLW	Unknown	Unknown	N/A	N/A
1.5h General Isotopes Area (3037, 3033, etc)	LLW, Ru-106, Pm-147, Hg	Unknown	Unknown	N/A	N/A

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents Volume (gal)	Sludge (gal)	Liquid (gal)
1.5i Bldg 3092 Area	LLW	Unknown	Unknown	N/A	N/A
1.5j Bldg 3026, Underneath	LLW	Unknown	Unknown	N/A	N/A
1.5k Bldg 3024, Between WC-1 and WC-5	LLW	Unknown	Unknown	N/A	N/A
1.5l Bldg 3085, ORR Pumphouse	Cd-115, Na-24, Sc-46, Cr-51, Co-60, Zr-95, Cs-137, Cs-141	Unknown	Unknown	N/A	N/A
1.5m Bldg 3028	LLW	Unknown	Unknown	N/A	N/A
1.5n Bldg 2531, East	LLW	Unknown	Unknown	N/A	N/A
1.5o Bldg 3515, Underneath	LLW	Unknown	Unknown	N/A	N/A
1.5p Bldg 3525, To a Sump	LLW	Unknown	Unknown	N/A	N/A
1.5q Bldg 3550, Underneath	LLW	Unknown	Unknown	N/A	N/A
1.5r Bldg 3500, Sewer	LLW	Unknown	Unknown	N/A	N/A
1.5s Abandoned Line, Central Avenue	LLW	Unknown	Unknown	N/A	N/A
1.5t Bldg 4508, North	LLW	Unknown	Unknown	N/A	N/A
1.5u Bldg 3518, West	Sr-90, Cs-137	Unknown	Unknown	N/A	N/A
1.5v Northwest of SWSA 1	LLW	Unknown	Unknown	N/A	N/A

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents: Volume (gal)	Current Contents: Sludge (gal)	Current Contents: Liquid (gal)
1.5w Bldg 3503, Ground Contamination	LLW	Unknown	Unknown	N/A	N/A
1.6 Contaminated Surfaces and Soil from 1959 Explosion in Bldg. 3019 Cell	Pu-239	$<4.7 \times 10^{2}$	Unknown	N/A	N/A
1.7 Contamination at Base of 3019 Stack	Co-60, Cs-137, Cm-244 Am-241, Pu-238, Pu-239	Presence unconfirmed	Unknown	N/A	N/A
1.8 Graphite Reactor Storage Canal Overflow (3001/3019)	Unidentified	Presence unconfirmed	Unknown	Unknown	N/A
1.9 ORR Decay Tank Rupture Site (3087)	Neutron activation products	Presence unconfirmed	Unknown	Unknown	N/A
1.10 Storage Pads (3503, 3504)	U-233, Pu-239	$<1.0 \times 10^{-1}$ est.	Unknown	Unknown	Unknown
1.11 Decommissioned Waste Holding Basin (3512)	Unidentified	$<1.0 \times 10^{1}$ est.	30,000[d]	Unknown	Unknown
1.12 Waste Holding Basin (3513)	PCB Sr-90 Cs-137 Pu-239	Unknown 3.0×10^{1} 2.0×10^{2} 5.0	1,880,000[e]	220,000	1,600,000
1.13 Equalization Basin (3524)	Sr-90 Cs-137 Th, U, TRU	3.0×10^{1} 1.0×10^{2} 1.1×10^{1}	1,000,000	Unknown	Variable
1.14 Process Waste Pond (3539)	Unidentified	$<1.0 \times 10^{1}$ est.	150,000	Unknown	Variable

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents: Volume (gal)	Sludge (gal)	Liquid (gal)
1.15 Process Waste Pond (3540)	Unidentified	$<1.0 \times 10^{1}$ est.	150,000	Unknown	Variable
1.16 East Sewage Aeration Pond (2543)	Unidentified	$<1.0 \times 10^{1}$ est.	1,000,000	Unknown	Unknown
1.17 West Sewage Aeration Pond (2544)	Unidentified	$<1.0 \times 10^{1}$ est.	1,000,000	Unknown	Variable
1.18 Coal Pile Settling Basin (2545)	Unidentified	Unknown	300,000	Unknown	Variable
1.19 LITR Pond (3085W)	Cs-137 Sr-90 Pu-239	20×10^{-3} 1×10^{-3} 0.1×10^{-3}	18,000[d]	Unknown	N/A
1.20 Filter Pit (3517)	Sr-90, Cs-137	Unknown	Unknown	Unknown	Unknown
1.21 FPDL LLW Transfer Line	Unidentified	$<1.0 \times 10^{3}$ est.	Unknown	Unknown	Unknown
1.22 Isotopes Ductwork/ Filter House (3110)	Unidentified	Unknown	Unknown	Unknown	Unknown
1.23a Inactive[f] Tanks (W-1)	Sr-90 Cs-137 Eu-152 Eu-154 TRU	9.0×10^{-2} 2.0×10^{-2} 3.0×10^{-2} 5.0×10^{-4} 7.0×10^{-4}	4,800	Unknown	1,000
1.23b Inactive Tank (W-2)	Sr-90 Co-60 Cs-137 Eu-152 Eu-154	1.0×10^{1} 4.0×10^{-2} 1.0×10^{1} 5.0 8.0×10^{-1}	4,800	500	800

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents Volume (gal)	Sludge (gal)	Liquid (gal)
1.23b Inactive Tank (W-2) (Continued)	Eu-155	3.0×10^{-2}			
	U-233	8.0×10^{-3}			
	U-235	3.0×10^{-4}			
	TRU	7.0			
1.24a Inactive Tank (W-3)	Sr-90	3.0×10^{1}	42,500	4,200	22,200
	Cs-137	1.0×10^{3}			
	U-233	1.0×10^{-2}			
	U-238	2.0×10^{-3}			
	TRU	2.0×10^{2}			
1.24b Inactive Tank (W-4)	Sr-90	1.0×10^{2}	42,500	5,800	11,600
	Cs-137	1.0×10^{2}			
	U-233	2.0			
	U-235	8.0×10^{-2}			
	U-238	2.0			
	TRU	4.2			
1.25a Inactive Tank (W-13)	Sr-90	3.0×10^{2}	2,000	Unknown	450
	Co-60	1.0×10^{-2}			
	Cs-137	3.0×10^{1}			
	Eu-154	1.0×10^{-1}			
	U-233	2.0×10^{-4}			
	U-235	2.0×10^{-5}			
	U-238	2.0×10^{-4}			
	TRU	4.3×10^{-2}			
1.25b Inactive Tank (W-14)	Sr-90	8.0	2,000	Unknown	120
	Co-60	3.0×10^{-2}			
	Cs-137	6.0			
	U-233	2.0×10^{-4}			
	U-238	3.0×10^{-5}			
	TRU	6.0×10^{-4}			

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents Volume (gal)	Sludge (gal)	Liquid (gal)
1.25c Inactive Tank (W-15)	Unidentified	Unknown	2,000	Unknown	Unknown
1.26a Inactive Tank (W-5)	Sr-90	300	170,000	6,000	Unknown
	Cs-137	20			
	Th-232, U, TRU	10			
1.26b Inactive Tank (W-6)	Sr-90	2,000	170,000	15,000	Unknown
	Cs-137	150			
	Th-232, U, TRU	40			
1.26c Inactive Tank (W-7)	Sr-90	2,000	170,000	Minimal	Unknown
	Cs-137	150			
	Th-232, U, TRU	40			
1.26d Inactive Tank (W-8)	Sr-90	2,000	170,000	1,000	Unknown
	Cs-137	150			
	Th-232, U, TRU	40			
1.26e Inactive Tank (W-9)	Sr-90	2,000	170,000	3,000	Unknown
	Cs-137	150			
	Th-232, U, TRU	40			
1.26f Inactive Tank (W-10)	Sr-90	2,000	170,000	40,000	Unknown
	Cs-137	960			
	Th-232, U, TRU	330			
1.27 Inactive Tank (W-11)	Sr-90	1.0×10^{-3}	1,500	45	260
	Cs-137	1.0×10^{-3}			
	TRU	1.0×10^{-3}			

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents Volume (gal)	Current Contents Sludge (gal)	Current Contents Liquid (gal)
1.28 Inactive Tank (W-1A)	Sr-90, Cs-137, U-233, TRU	Unknown	4,000	Unknown	Unknown
1.29 Inactive Tank (WC-1)	Sr-90	$<1.0 \times 10^{1}$ est.	2,000	Unknown	Unknown
	Cs-137	$<1.0 \times 10^{1}$ est.			
	TRU	$<1.0 \times 10^{-1}$ est.			
1.30a Inactive Tank (WC-15)	Sr-90, Cs-137, TRU	$<1.0 \times 10^{-1}$ est.	1,000	Unknown	Unknown
1.30b Inactive Tank (WC-17)	Sr-90	2.2×10^{-3}	1,000	80	950
	Co-60	2.2×10^{-5}			
	Cs-137	5.2×10^{-4}			
	Eu-154	1.1×10^{-5}			
	TRU	1.2×10^{-3}			
1.31a Inactive Tank (TH-1)	Sr-90	6.0×10^{-1}	2,500	Unknown	475
	Co-60	1.0×10^{-2}			
	Cs-137	5.0×10^{-1}			
	Th-232	3.0×10^{-6}			
	TRU	2.0×10^{-4}			
1.31b Inactive Tank (TH-2)	Sr-90, Cs-137, Th-232, TRU	Unknown	2,400	Unknown	Unknown
1.31c Inactive Tank (TH-3)	Sr-90	6.0×10^{-1}	3,300	Unknown	700
	Co-60	5.0×10^{-4}			
	Cs-137	6.0×10^{-1}			
	Th-232	1.0×10^{-6}			
	TRU	2.0×10^{-4}			

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents Volume (gal)	Sludge (gal)	Liquid (gal)
1.32 Inactive Tank (TH-4)	Sr-90 Cs-137 Th-232 TRU, U	6.0×10^{-2} 5.0×10^{-1} 1.0×10^{-5} 8.5×10^{-2}	14,265	5,500	9,800
1.33 Active Tank (2026)	Unidentified	Unknown	500	Unknown	Variable
1.34 Active Tank (WC-2)	Unidentified	Unknown	1,000	Unknown	Variable
1.35 Active Tank (WC-3)	Unidentified	Unknown	1,000	Unknown	Variable
1.36 Inactive Tank (WC-4)	Unidentified	Unknown	1,700	Unknown	Unknown
1.37a Active Tank (WC-5)	LLW	Unknown	1,000	Unknown	Variable
1.37b Active Tank (WC-6)	LLW	Unknown	5,000	Unknown	Variable
1.37c Active Tank (WC-8)	LLW	Unknown	1,000	Unknown	Variable
1.37d Active Tank (WC-9)	LLW	Unknown	2,140	Unknown	Variable
1.38 Active Tank (WC-7)	LLW	Unknown	1,100	Unknown	Variable
1.39a Active Tank (WC-10)	LLW	Unknown	2,300	Unknown	Variable
1.39b Active Tank (WC-11)	LLW	Unknown	4,600	Unknown	Variable
1.39c Active Tank (WC-12)	LLW	Unknown	1,000	Unknown	Variable
1.39d Active Tank (WC-10)	LLW	Unknown	1,000	Unknown	Variable
1.39e Active Tank (WC-14)	LLW	Unknown	1,000	Unknown	Variable

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents Volume (gal)	Sludge (gal)	Liquid (gal)
1.40 Active Tank (WC-19)	LLW	Unknown	2,100	Unknown	Variable
1.41 Active Tank (W-12)	LLW	Unknown	700	Unknown	Variable
1.42a Active Tank (W-16)	LLW	Unknown	1,000	Unknown	Variable
1.42b Active Tank (W-17)	LLW	Unknown	1,000	Unknown	Variable
1.42c Active Tank (W-18)	LLW	Unknown	1,000	Unknown	Variable
1.43a Active Tank (W-21)	LLW	Unknown	50,000	Unknown	Variable
1.43b Active Tank (W-22)	LLW	Unknown	50,000	Unknown	Variable
1.44 Active Tank (W-23)	LLW	Unknown	50,000	Unknown	Variable
1.45a Active Tank (C-1)	LLW	Unknown	50,000	Unknown	Variable
1.45b Active Tank (C-2)	LLW	Unknown	50,000	Unknown	Variable
1.46 SWSA 1 (2624)	Sr-90, Unidentified Hz[g]	$<4.0 \times 10^3$ Unknown	Unknown	N/A	N/A
1.47 SWSA 2 (4003)	Unidentified	Presence unconfirmed Contents moved to SWSA 3 before 1950	Unknown	N/A	N/A
1.48 LLW Evaporator (2531)	Unidentified	Unknown	Unknown	Unknown	Unknown
1.49 Neutralization Facility (3518)	Unidentified	Unknown	40,000	Unknown	Unknown

TABLE 3-10 (Continued)

SWMU Site[a]	Contaminant	Inventory[b] [Ci (kg)]	Current Contents		
			Volume (gal)	Sludge (gal)	Liquid (gal)
1.50 PCB Storage Area (2018N)	Unidentified	Unknown	Unknown	Unknown	Unknown
1.51 PWTP (3544)	Unidentified	Unknown	Unknown	Unknown	Unknown
1.52 Sewage Treatment Plant (2521)	Presence Unconfirmed	Unknown	Unknown	Unknown	Unknown
1.53 Bldg. 3000 Septic Tank (3078)	Unidentified	Presence Unconfirmed	580	Unknown	Unknown
1.54 Waste Oil Storage Tanks (2525)	Unidentified	Unknown	1,000	Unknown	Unknown

[a]Items in parentheses are associated building number or tank number.

[b]Numbers in parentheses are measured in kilograms; all others are in curies.

[c]LLW is the radioactive and chemical waste generated by ORNL activities and collected by the LLW collection and transfer system. No routine effort has been made to determine the composition of the waste stream. It has been estimated that the average activity is about 30 mCi/gal and the major radionuclides present are Sr-90, Cs-137, Co-60, and various rare earths, with some plutonium, uranium, and TRU isotopes present.

[d]Impoundment has been filled in.

[e]Liquid and sediments.

[f]Inactive refers to tanks no longer receiving new waste additions; most are still storing liquid wastes and/or sludges. Active refers to tanks that are in use for waste collection and storage of newly generated wastes.

[g]Hz refers to hazardous wastes.

1 Bq = 27.03 pCi
1 Ci = 10^{12} pCi

Waste Tank 2026 (SWMU 1.33)

Tank 2026 is an underground stainless steel tank that collects low-level waste (LLW) streams from Building 2026 and discharges to Tank W-1A. Waste transfer lines are Hastalloy.

Waste Tank WC-2 (SWMU 1.34)

Only LLW streams contaminated with iodine-131 from Buildings 3028, 3038, and 3110 are routed to this stainless steel tank. Waste transfer lines into and out of the tank are stainless steel.

Waste Tank WC-3 (SWMU 1.35)

This stainless steel tank collects the LLW streams from Buildings 3025 and 3110. Waste transfer lines are stainless steel.

Waste Tank WC-4 (SWMU 1.36)

This stainless steel tank collects the LLW streams from Building 3026. Waste transfer lines are stainless steel.

Waste Tanks WC-5, WC-6, WC-8 and WC-9 (SWMU 1.37a-d)

Tank WC-6 collects LLW from Buildings 3508, 3541, and 3592. Tank WC-9 collects LLW from Building 3503 and the central off-gas condensate system. Tanks WC-5 and WC-8 receive waste from Buildings 3503 and 3508, respectively. The tanks and waste transfer lines are stainless steel.

Waste Tank WC-7 (SWMU 1.38)

Tank WC-7 collects the LLW streams from Building 3504. The tank and waste transfer lines are stainless steel.

Waste Tanks WC-10, WC-11, WC-12, WC-13, and WC-14 (SWMU 1.39)

Tank WC-10 collects LLW from the radioisotope processing area, 3039 stack drain, and the 3092 scrubber. Tank WC-11 receives waste from Buildings 4500N (Wing 1), 4505, 4507, and 4556. Tank WC-12 collects wastes from Building 4505. Tank WC-13 collects LLW from Buildings 4500S, 4500N, 4507, and 4508. Tank WC-14 receives wastes from Buildings 4501 and 4507. The tanks and collection and transfer lines are stainless steel.

Waste Tank WC-19 (SWMU 1.40)

This stainless steel tank collects waste from Buildings 3001, 3002, 3003, 3004, 3005, 3008, 3104, 3010, and 3042. Waste transfer lines are stainless steel.

Waste Tank W-12 (SWMU 1.41)

Tank W-12 collects LLW streams from Building 3525 and the tank farm pit (Building 3517). The tank and waste transfer lines are stainless steel.

Waste Tanks W-16, W-17, and W-18 (SWMUs 1.42a-c)

The tanks collect LLW from the 3500 area cell ventilation duct. The tanks and waste transfer lines are stainless steel.

Waste Tanks W-21 and W-22 (SWMUs 1.43a, b)

Tanks W-21 and W-22 are contained within a concrete vault and are associated with waste evaporator operations. The tanks and transfer lines are stainless steel.

Waste Tank W-23 (SWMU 1.44)

Tank W-23 is contained with a concrete vault and receives concentrate from the waste evaporator. The tank and transfer lines are stainless steel.

Waste Tanks C-1 and C-2 (SWMUs 1.45a, b)

Tanks C-1 and C-2 are stainless steel and are located in a concrete vault. They are used (along with Tank W-23) to store concentrate from the waste evaporator before it is transferred to Tanks W-24 to W-31 at the hydrofracture sites in Melton Valley. Most of the transfer lines associated with these tanks are doubly contained stainless steel.

3.2.1.2 Inactive Tanks. Forty-nine radioactive and mixed waste collection and storage tanks have been installed at WAG 1 since operations at ORNL began. Of the existing tanks, 25 are now inactive; 24 active tanks continue to be used in support of waste management operations.

The BNI RI/FS addresses only the effort for characterization and remediation of the environmental contamination associated with the inactive tanks. Energy Systems is responsible for the characterization of the contents of the inactive tanks and any subsequent remedial activities associated with the tank system and its contents. Energy Systems is also responsible for all aspects of the active tank program.

Three of the inactive tanks (W-19, W-20, and T-30) were not addressed in the original WAG 1 RI Plan. Tanks W-19 and W-20 were added to the SWMU listing after the WAG 1 RI Plan was issued, and Tank T-30 is going to be added to the SWMU list in the near future (Nix, 1989). These tanks are discussed in the following paragraphs.

Waste Tanks W-19 and W-20 (SWMUs 1.56a and 1.56b)

Tanks W-19 and W-20 are located south of the South Tank Farm near Fourth Street. These tanks were installed in 1955 to serve the MRF and were used to collect waste produced during recovery and reprocessing of uranium and other nuclear material. The waste material mainly consisted of acidic fission product raffinate solutions (nitric acid waste), which were produced by the extraction process evaporator in Cell B of the Metal Recovery Facility (MRF). The raffinate solutions were eventually transferred from Tanks W-19 and W-20 to Building 3517 for separation of fission products (UCC-ND, 1984).

Tanks W-19 and W-20 are small, vertical, stainless steel tanks with a capacity of 2,250 gal. These underground tanks rest on a common concrete pad and have an associated jet pit located waste of them.

The MRF was decommissioned in 1960 after an explosion at the Hot Pilot Plant (Building 3019). Following this event, Tanks W-19 and W-20 were used briefly by Building 3517 before being placed out of service in the 1960s. An attempt was made in the 1987-1989 effort to sample these tanks, but they were found to be empty (Autrey et al., 1989).

Waste Tank T-30

Tank T-30 was installed in a concrete vault south of Building 4507 in 1945 and used to store radioactive materials for the Curium Recovery Facility (Building 4507), which became the High Radiation Level Chemical Recovery Facility in 1973. The tank was inspected in 1961 by Inspection Engineering and found adequate for storage of radioactive materials. In 1963, the south wall of the tank vault required repair due to infiltration of water. Apparently this infiltration was due to a high groundwater table, which exceeded the height of the stainless steel liner in the vault and resulted in leakage.

Tank T-30 is a small, stainless steel-jacketed, vertical, underground tank with a capacity of 825 gal. No out-of-service date is available for this tank. Tank T-30 is not known to be leaking. Tank T-30 does not currently have a SWMU number associated with it, but it should be listed with its designated number in the next annual SWMU update (Nix, 1989).

Sampling of Inactive Tank Contents

The 25 inactive tanks in WAG 1 are listed in Table 3-10a by SWMU number and tank designation (for locations, see Figure 3-6). As part of the Remedial Action Program (RAP), ORNL sampled 22 of these tanks during the period 1987 to 1989. Three inactive tanks (Tanks WC-1, WC-15, and TH-2) have not yet been sampled because of inaccessibility and/or the presence of high levels of radiation. These tanks will be sampled at the beginning of FY 1990 (Autrey, 1989). The following summarizes the findings of the sampling/analysis effort. At present, data are considered only suitable for use in scoping and to assist in developing the sampling plan for characterization of environmental contamination around the inactive tanks.

Grab samples were collected from 20 of these tanks. An attempt was made to sample Tanks W-19 and W-20, but they were found to be empty. As shown in Table 3-10a, each sample consisted of a liquid phase; other phases included hard and soft sludge. Samples were analyzed for physical parameters, anions, radiochemical parameters, TCL metals, TCL volatile organic compounds, and TCL semi-volatile organic compounds.

Results of only the radiochemistry analyses, TCL metals, volatiles, and semi-volatiles are discussed here. ORNL reported the results of data validation for the organics analyses; data were flagged by ORNL with qualifiers. The organics results presented here include only data that were either not flagged or flagged with only a "J" qualifier, which indicates the analyte

TABLE 3-10a

INACTIVE TANKS IN WAG 1

SWMU	Inactive Tank	Sampled 1987-89	Sample Phase[a]
1.23a	W-1	Yes	L
1.23b	W-2	Yes	L
1.24a	W-3	Yes	L,S
1.24b	W-4	Yes	L,S,H
1.25a	W-13	Yes	L
1.25b	W-14	Yes	L
1.25c	W-15	Yes	L
1.26a	W-5	Yes	L,S
1.26b	W-6	Yes	L,S
1.26c	W-7	Yes	L,S,H
1.26d	W-8	Yes	L,S
1.26e	W-9	Yes	L,S
1.26f	W-10	Yes	L,S,H
1.27	W-11	Yes	L,H
1.28	W-1A	Yes	L
1.29	WC-1	No	---
1.30a	WC-15	No	---
1.30b	WC-17	Yes	L,S
1.31a	TH-1	Yes	L
1.31b	TH-2	No	---
1.31c	TH-3	Yes	L
1.32	TH-4	Yes	L,S
1.56a	W-19	No	Empty
1.56b	W-20	No	Empty
(b)	T-30	Yes	L

[a] Sample phase: L = liquid, S = sludge, H = hard sludge.

[b] Tank T-30, which is located in WAG 1 south of Building 4507, has not yet been issued a SWMU number; but discussion with Caroll Nix, Energy Systems, indicates that it will be issued a number in the near future.

was present in the sample but at levels less than the ORNL reporting limit.

For purpose of discussion, the tanks are grouped into seven areas as follows:

- Area 1--North Tank Farm (Waste Tanks W-1, W-2, W-3, W-4, W-13, W-14, W-15, W-1A)
- Area 2--South Tank Farm (Waste Tanks W-5, W-6, W-7, W-8, W-9, W-10)
- Area 3--Building 3550 Laboratories Waste Tank W-11, Buildings 3505 and 3517 Waste Tanks W-19 and W-20
- Area 4--Building 3550 Waste Tank TH-4
- Area 5--3000 Area Waste Tank WC-1
- Area 6--Building 4500 Laboratories Waste Tanks WC-15 and WC-17 and Building 4507 Waste Tank T-30
- Area 7--Building 3503 Waste Tanks TH-1, TH-2, and TH-3

This grouping is proposed because subsequent soil and groundwater sampling around the tanks probably would not be able to differentiate among individual tanks; also, environmental remediation would likely be for the area around the tank group and not be directed at individual tanks within the area.

Area 1--North Tank Farm. The North Tank Farm (NTF) consists of Tanks W-1, W-1A, W-2, W-3, W-4, W-13, W-14, and W-15. Tanks W-1 and W-2 (SWMUs 1.23a and 1.23b) received LLW from Building 3019 and other facilities, with Tank W-2 normally receiving overflow from W-1. These underground tanks are 4,800-gal capacity, dome-shaped Gunite tanks with steel reinforcement. These tanks were constructed in 1943 and removed from service in the early 1960s.

Tank W-1A (SWMU 1.28) received various waste streams from Building 3019 and served as a collection tank for all wastes from Building 2026. The tank and waste transfer lines are stainless steel except for the Hastalloy discharge line from Building 2026.

The underground tank is a 4,000-gal capacity, horizontal tank. Tank W1-A was installed in 1951 and taken out of service in 1986 due to groundwater infiltration (PEER and MCI, 1987).

Tanks W-3 and W-4 (SWMUs 1.24a and 1.24b) received LLW from Building 3019. Tank W-3 collected plutonium waste; W-4 collected uranium wastes. These underground tanks are 42,500-gal capacity, dome-shaped Gunite tanks; wastes were neutralized to prevent corrosion of the concrete. The tanks were constructed in 1943 and were removed from service in the 1960s because groundwater was reported to be entering the tanks.

Tanks W-13, W-14, and W-15 (SWMUs 1.25a-c) received LLW from the metal waste drains in Building 3019 and chemical waste for fission product recovery. Tank W-13 served the Chemistry Division's Hot Laboratory, and Tanks W-14 and W-15 served the Operations Division's Radioisotope Department. Tanks W-13 and W-14 are horizontal tanks, and W-15 is a vertical tank. These underground tanks are stainless steel, 2,000-gal capacity tanks, which are encased in concrete for containment and shielding. The tanks were installed in 1940 and were taken out of service in 1958 because they were no longer needed.

From the NTF tanks, waste samples of liquid (L), soft sludge (S), and hard sludge (H) were collected. In some of the tanks, the contents were classified by ORNL staff as RCRA or mixed waste liquids and sludges because of high levels of chromium, mercury, lead, nickel, and cadmium in the liquids; and high levels of cadmium, chromium, lead, and mercury in the sludges. Other metals found in the samples are uranium, silver, barium, and selenium (H). ORNL classified liquids in two of the tanks (W-14 and W-15) as being corrosive RCRA liquid waste with pH between 0.2 and 0.6.

Radiochemical analyses showed the wastes are contaminated with Cs-137, Co-60 (L,S), Sr-90, H-3, U-233, U-238, Pu-238 (L,S), Pu-239, Cm-244 (L), Am-241 (L), Cs-134 (L), Th-228/232 (L), U-232 (L), and Eu-154 (L,S). If there is not an identifier following the element, this indicates its presence in all phases. Two of the tanks (W-3 and W-4) have been classified by ORNL as containing TRU sludges (Autrey et al., 1989). In addition, a 1984 sampling effort by Huang et al. (1984) found that Tank W-2 contained TRU sludges. Autrey's 1989 effort did not include sampling Tank W-2 sludges. TRU is defined by ORNL as the presence of alpha emitters with half lives greater than 20 years and activities in excess of 3.7x103 Bq/g (100 nCi/g).

Volatile organic compounds that were reported for the waste liquids are methyl alcohol, 2-butanone, acetone, trichloroethene, 4-methyl-2-pentanone, chlorobenzene, and naphthalene. Semi-volatile organics found in the waste sludges are bis(2-ethylhexyl)phthalate, di-n-butylphthalate, and other unreported polyaromatic hydrocarbons (PAHs). Organics detected in the waste but below reporting limits are benzene, diethylphthalate, fluoranthene, phenanthrene, pyrene, chrysene, and di-n-octylphthalate.

Area 2--South Tank Farm. The South Tank Farm consists of waste tanks W-5, W-6, W-7, W-8, W-9, and W-10 (SWMUs 1.26a-f). These 160,000-gal capacity underground tanks are the largest-capacity Gunite tanks at ORNL. The tanks are arranged in a 60-ft center-to-center grid of two rows of three tanks each. They were used mainly for storage of LLW before treatment/disposal but were removed from service because of concerns regarding deterioration of the gunite.

From these tanks, waste samples of liquid (L), soft sludge (S), and hard sludge (H) were collected. The contents of the tanks were classified by ORNL as RCRA waste liquids and sludges because of the high levels of chromium and mercury in the liquids and cadmium, chromium, lead, and mercury in the sludges. Other metals found in the tank samples are uranium, silver, arsenic, barium, nickel, and selenium (S). The pH of the liquids in the tanks range from 8.7 to 10.9.

Radiochemical analyses showed the wastes are contaminated with Cs-137, Co-60, Sr-90, H-3, U-233, Pu-238, Pu-239, Cm-244 (H,S), Am-241 (S), Cs-134, Th-228/232, Eu-152 (S), Eu-154 (S,H), and Eu-155 (S). Three of the tanks (W-7, W-8, and W-9) have been classified by ORNL as containing TRU sludges.

Volatile organic compounds that were found in the liquids are trichloroethene, tetrachloroethene, chloroform, benzene, 2-butanone, 2-hexanone, 4 methyl-2-pentanone, acetone, methyl alcohol, n-butyl alcohol, chlorobenzene, ethyl alcohol, toluene, and 1,2-dichloroethene (total). Semi-volatile organic compounds that were detected include bis(2-ethylhexyl)phthalate and benzoic acid. Organics detected but below reporting limits are di-n-butylphthalate, diethylphthalate, fluoranthene, phenanthrene, pyrene, naphthalene, 2-methylnaphthalene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(a)anthracene, and chrysene.

<u>Area 3--Tanks W-11, W-19, and W-20</u>. Tank W-11 (SWMU 1.27) received LLW from laboratories in Building 3550. This underground tank is a 1,500-gal capacity dome-shaped Gunite tank with steel reinforcement. This tank was constructed in 1943 and was removed from service in 1948 because of leaks.

Tanks W-19 and W-20 were described at the beginning of Section 3.2.1. These tanks were sampled during the 1987-1989 effort but were found to be empty (Autrey et al., 1989).

Tank W-11 samples included both liquid (L) and hard sludge (H). The sludge in the tank is classified as RCRA waste because of high levels of chromium, lead, and mercury. Other metals found in the waste samples are uranium (L), arsenic (H), barium, cadmium (H), and nickel (H). The pH of the liquid was between 7.7 and 8.

Radiochemical analyses identified as contaminants were Sr-90 (L), H-3 (L), and C-14 (L).

Volatile organics compounds were detected in the liquid samples but were below reporting limits; they are chlorobenzene and trichloroethene. Semi-volatile organics were reported for the sludge as follows: the PAHs benzo(a)anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, chrysene, ideno(1,2,3-CD)pyrene, phenanthrene, pyrene, and the phthalates bis(2-ethylhexyl) phthalate and di-n-butylphthalate.

Tank Area 4--Tank TH-4. Tank TH-4 (SWMU 1.32) collected waste from thorium and uranium pilot plant development studies conducted in Building 3550. This tank is a 14,000-gal capacity, underground, dome-shaped tank constructed of Gunite with steel reinforcement. The tank was constructed in 1943 and was taken out of service in 1970. It is reportedly filled with alkaline thorium and uranium sludge.

Tank TH-4 samples included both liquid and soft sludge. ORNL classified the contents as RCRA waste liquids and sludges because of high levels of chromium in the liquid and chromium, silver, arsenic, barium, cadmium, and nickel in the sludge. Other metals found in the waste include uranium, silver (S), and mercury. The pH of the liquid ranged from 5.8 to 7.8.

Radiochemical analyses showed that the wastes were contaminated with Cs-137, Co-60, Sr-90, H-3, U-233 (S), Pu-239 (S), Th-228/Th-232, and C-14 (L).

Volatile organic compounds detected in the samples include benzene, chloroform, carbon tetrachloride, 2-butanone, xylene (total), chlorobenzene, trichloroethene, acetone, methyl alcohol, 4-methyl-2-pentanone, and n-butyl alcohol. Semi-volatile organic compounds detected in the samples are as follows: the PAHs anthracene, benzo(a)anthracene, benzo(b)fluoranthene, chrysene, fluoranthene, naphthalene, phenanthrene, pyrene, and acenaphthene; bis(2-ethylhexyl)phthalate and phanante were also found. Organics that were detected but below the reporting limits are benzo(a)pyrene, benzo(g,h,i)perylene, fluorene, ideno(1,2,3-cd)pyrene, and dibenzofuran.

<u>Area 5--Tank WC-1</u>. Tank WC-1 (SWMU 1.29) was used for collection and monitoring of process liquid waste from isotope production and development laboratories in Buildings 3038, 3028, 3029, 3030, 3031, 3032, 3033, 3047, filter Building 3110, stack 3039, and scrubber 3092. This underground tank is a 2,150-gal capacity, vertical, stainless steel tank. It was placed in service in 1950 and was taken out of service in 1968 because of leaking discharge lines. Tank WC-1 has not yet been sampled due to lack of large enough ancillary equipment for insertion of a sampling device. Process for sampling by means of uncovering the tank is planned for the beginning of FY 1990 (Autrey, 1989).

<u>Area 6--Tanks WC-15, WC-17, and T-30</u>. Tanks WC-15 and WC-17 (SWMUs 1.30a and 1.30b) collected waste from various laboratories in the Building 4500 complex. These underground tanks are 1,000-gal capacity, vertical, stainless steel tanks, which were placed in service in 1951 and were removed from service in the 1960s because of leaks.

Waste Tank WC-15 has not been sampled due to access restrictions. Access for sampling by means of uncovering the tank is planned for the beginning of FY 1990 (Autrey, 1989). Waste materials sampled in Tank WC-17 include liquids (L) and the soft sludge (S). The contents of the tank were classified as RCRA liquids and RCRA sludge by ORNL because of high levels of mercury in the liquid and cadmium, chromium, lead, and mercury in the sludges. Other metals identified were uranium, silver (S), arsenic (S), barium, and nickel (S). The pH of the liquid waste ranged from 7.6 to 7.9.

Radiochemical analyses determined the presence of Cs-137, Co-60 (S), Sr-90 (S), H-3, Pu-238 (S), Pu-239 (S), Cm-244 (S), Am-241 (S), Th-228/232 (L), Eu-154 (S), and Eu-155 (S).

Volatile organics reported for the liquid samples include styrene and xylene (total). Volatiles detected but below the reporting limit are trichloroethene and vinyl acetate. The semi-volatile compound reported for the liquid is bis(2-ethylhexyl)phthalate; it was below the reporting limit. Also found in the samples were PCBs including Aroclor-1254 and Aroclor-1260.

Sampling of the liquid phase in Tank T-30 resulted in determination of 11 mg/L of methanol and a trace of phthalate. These findings are in line with the low TOC, 13.7 mg/L.

<u>Tank Area 7--Tanks TH-1, TH-2, and TH-3</u>. Tanks TH-1, TH-2, and TH-3 (SWMUs 1.31a-c) received wastes from the Thorium Pilot Plant in Building 3503. Tank TH-1 is an underground, 2,500-gal capacity, vertical, stainless steel tank, which was placed in service in 1948. Tank TH-2 is an underground, 2,400-gal capacity, vertical, stainless steel tank, which was placed in service in 1952. Tank TH-3 is an underground, 3,300-gal capacity, vertical, stainless steel tank, which was placed in service in 1952. All three tanks were taken out of service in 1970, and the structural integrity of these tanks is unknown.

Tank TH-2 was not sampled due to access restrictions. Samples from Tanks TH-1 and TH-3 were liquids. Tank contents are characterized as RCRA liquids because of their corrosive nature (pH 1.8) and high levels of mercury; other metals near the RCRA limits are chromium and lead. Other metals detected, but at lower levels are uranium, silver, barium, and nickel.

Radiochemical analyses showed that wastes are contaminated with Cs-137, Sr-90, H-3, U-233, Th-228/Th-232, and C-14.

3.2.1.3 <u>Sewage and Chemical Waste Tanks</u>. Brief descriptions of the sewage and chemical waste tanks are provided below.

<u>Septic Tank for Building 3000 (SWMU 1.53)</u>

This small, 580-gal septic tank serves Building 3000. The tank is located outside the WAG 1 boundary.

<u>Waste Oil Storage Tanks (SWMU 1.54)</u>

Two 500-gal steel waste oil storage tanks are located on the southeast side of Building 2325. One stores waste oil, and the other stores soluble oil. The tanks are contained in a diked area, and no releases have been reported.

3.2.2 Leak and Spill Sites

Thirty-four leak/spill sites have been identified in WAG 1. Of these, 23 are sites of spills or leaks that have occurred in the LLW collection and transfer lines; 7 are sites where radionuclide contamination has resulted from past and ongoing ORNL operations; and 4 are sites contaminated with hazardous chemicals (mercury).

In general, most of the radionuclide leak/spill sites and contaminated areas are in the vicinity of the North and South Tank Farms and the isotopes production areas (Figure 3-5). The chemical spill sites are in the vicinity of the 4500 and 3500 areas of the plant (eastern and southern portions of WAG 1). In many instances, specific information on the volume of leakage and the extent of the leaks is not available. Grimsby (1986a, b) has compiled existing data on the ORNL LLW leak and spill sites, and Saylor (1986) has compiled similar information on the chemical leak and spill sites.

3.2.2.1 Radioactive Leaks and Spills. Brief descriptions of each of the radioactive leaks and spills sites are provided below.

LLW Leak and Spill Site - Building 3020, South (SWMU 1.5a)

The initial leak occurred in the mid-1970s when a sight glass in the header froze and broke. Later, a restriction downline caused a backup of waste to occur, with a resulting overflow at both locations. Leakage from this site has contaminated the storm drainage system north of Building 3074 from east to west. Major radionuclides involved were reported to be isotopes of plutonium, strontium, and cesium.

LLW Leak and Spill Site - Building 3020, East (SWMU 1.5b)

This leak is believed to have occurred some 25 years ago, possibly from exhaust gas ducts. A 1970 contamination survey of the area showed 20 mR/h on topsoil and alpha readings of 10 mR/h. Most of the contamination is reported to be in the soil and the concrete pa

LLW Leak and Spill Site - Building 3082, West (SWMU 1.5c)

This leak is thought to have occurred over 25 years ago. Readings in the area ran 1-2 mR/h in the 1970s surveys. The contamination was most likely caused by off-gas duct leakage or a LLW line leak; however, no documentation exists regarding the source.

LLW Leak and Spill Site - Building 3019, North (SWMU 1.5d)

This LLW line leak occurred in a concrete-encased chemware line that served the manipulator shop upstream of the leak site and the Building 3020 stack. When the leak occurred is unknown; however, it was discovered in February 1985 after higher-than-normal levels of strontium-90 were found in the sewer system.

The leak occurred at the T in the line. Excavation was conducted to provide access to the leak. Upon excavation, a cavern was found in the area. No attempt was made to remove all of the contaminated soil, but contaminated soil with radiation levels of 100 mR/h maximum was removed and disposed of. The north and south lines to the T were capped, and the excavation was backfilled with clean earth.

LLW Leak and Spill Site - Building 3019, Southwest (SWMU 1.5e)

This leak site is located in the LLW line draining the analytical cells. The leaks occurred in the 1970s, with the last leak apparently occurring in 1978. After the last occurrence, the leak was corrected, and during the repair, some soil was removed to gain access to the line. Samples of this soil measured 100 mR/h. The line was known to contain strontium-90, cobalt-60, mixed fission products, and alpha emitters.

LLW Leak and Spill Site - Building 3110, Between W-5 and WC-19 (SWMU 1.5f)

A leak was reported in the LLW transfer line between tanks W-5 and WC-19 in the North Tank Farm on October 16, 1972. The leak contaminated an area with cadmium-115, cerium-141, barium-140, and niobium-95 (all known contaminants in the ORR coolant). Dose measurements of 700 mR/h were noted in the earth around the leak area, and readings of 20-600 mR/h were found in mud in a half-round drain tile extending eastward to a storm sewer catch basin.

LLW Leak and Spill Site - Building 3047, Underneath (SWMU 1.5g)

It is suspected that this site has underground contamination due to its history of operations. Few documented cases were found in records; however, certain existing documents indicate the presence of contamination, particularly strontium-90.

LLW Leak and Spill Site - General Isotopes Area (SWMU 1.5h)

This area is known to be contaminated with cesium-137, cobalt-60, ruthenium-106, strontium-90, and possibly mercury. Various accounts indicate that promethium-147 may also have been involved in some of the spills or leaks. It appears that a number of spills or leaks have occurred since the 1950s and 1960s.

LLW Leak and Spill Site - Building 3092 Area (SWMU 1.5i)

Little information exists for this leak site, which was included in a January 1972 tabulation of contaminated areas. Based on available information, it appears that the site was dug up and contaminated dirt was replaced with clean dirt.

LLW Leak and Spill Site - Building 3026, Underneath (SWMU 1.5j)

Because Building 3026 has been long involved in isotope production, the ground beneath and around it is likely contaminated from spills and leaks that occurred during the 1950s and 1960s. Numerous leaks and spills are referenced in Operations Division reports, though few quantitative data exist. However, due to the nature of the operations conducted in Building 3026, it is possible that contamination could include isotopes of uranium, fission products, and transuranics.

LLW Leak and Spill Site - Building 3024, Between WC-1 and W-5 (SWMU 1.5k)

This site reportedly is the result of a leak in the waste transfer line between WC-1 and W-5. However, other reported information suggests that a number of leaks from other sources may be contributing to the contamination. Likely contaminants of concern are strontium-90, cesium-137, ruthenium-106, cobalt-60, and various rare earths.

LLW Leak and Spill Site - Building 3085, Oak Ridge Research Reactor Pumphouse (SWMU 1.5l)

This leak occurred in the 24-in. primary coolant water line, which contained neutron activation products. Following repair of the leak, a concrete wall was poured on each side of the pipeline and an aluminum plate was laid across the line to the walls. During excavation, radiation levels up to 100 R/h were encountered, with transferable contamination measuring up to 100 mR/h. Contaminated soil was removed and buried in SWSA 6. Contamination was reported to be primarily cadmium-15, with traces of sodium-24, scandium-46, chromium-51, zirconium-95, cesium-137, cobalt-60, and cesium-141.

LLW Leak and Spill Site - Building 3028 (SWMU 1.5m)

A leak in the LLW line was discovered during excavation for the construction of a drain trap. At the contact with the pipe, radiation levels of over 200 R/h were observed in contaminated soil. New lines were installed to bypass the contaminated area. At the point of the leak, contaminated soil was removed and the hole was backfilled with clean soil. The leaking section of pipe was abandoned in place, and no attempt was made to remove all contaminated soil.

LLW Leak and Spill Site - Building 2531, East (SWMU 1.5n)

A leak was reported in the early 1970s due to a leak in an underground crossover between a storm sewer and the process waste line from the evaporator. Strontium-90 was the major contaminant of concern. In a later event in the same general area, an abandoned cast iron waste transfer line leading to the LLW evaporator was broken by a communications construction group during trenching operations.

LLW Leak and Spill Site - Building 3515, Underneath (SWMU 1.5o)

The area under Building 3515 is contaminated as the result of its past use as a radiochemical processing plant. Radioactive material leaking into the condensate line was carried to the concrete drain pipe leading to WOC. About 100 ft south of Building 3515, a joint in the pipe leaked contamination to a ditch and surrounding areas. The contaminated earth in and near the ditch was removed.

In another leak reported in the same general area, a pipe trench being dug at the southeast corner of the South Tank Farm became highly contaminated when a weld failed in a process tank jacket in Building 3515. The water from the jacket was piped to the storm sewer located in the area. The area has been cleaned up by removing the contaminated soil.

LLW Leak and Spill Site - Building 3525, to a Sump (SWMU 1.5p)

In this approximate area, severe contamination has resulted from leaking LLW lines discharging contaminated water into a ventilation duct, which in turn drains into a sump located in the area.

LLW Leak and Spill Site - Building 3550, Underneath (SWMU 1.5q)

The ground beneath the former semi-works parts of Building 3550 may be contaminated. This part of the building was demolished, and all materials were taken to the burial ground for disposal.

LLW Leak and Spill Site - Building 3500, Sewer (SWMU 1.5r)

Contamination of the 3500 block area of the sanitary sewer system has resulted from inleakage from various LLW sources in Building 3026 and other radioisotope processing areas. The leaks were of active solutions of radioisotopes; waste composition data and the dates of the leaks were not reported. Leaks may have been occurring in this area since operations at ORNL began.

LLW Leak and Spill Site - Abandoned Line, Central Avenue (SWMU 1.5s)

The leak into the sewer probably originated from earth contaminated by an old intermediate-level waste line that leaked and was taken out of service years ago.

LLW Leak and Spill Site - Building 4508, North (SWMU 1.5t)

The ground at this site is described as contaminated with strontium-90. Attempts to locate the source of the contamination were unsuccessful. Since the reported contamination, the area has been paved.

LLW Leak and Spill Site - Building 3518, West (SWMU 1.5u)

In May 1978 a radioactive leak of less than 100 gal was discovered along Third Street opposite the Equalization Basin (Building 3524). The material leaked was concentrated strip solution from the Process Waste Treatment Plant (PWTP) (Building 3544), and the solution contained low-level amounts of strontium-90 and cesium-137. The line was punctured by an airhammer during the installation of a waste transfer line from Building 1504. The spill required the removal of about 5 yd^3 of contaminated dirt.

LLW Leak and Spill Site - Northwest of SWSA 1 (SWMU 1.5v)

A break occurred in the LLW transfer line to Melton Valley northwest of SWSA 1, permitting leakage into WOC. No information is reported on the volume of waste or its activity level.

LLW Leak and Spill Site - Building 3503, Ground Contamination (SWMU 1.5w)

The contamination reported at this site resulted from a series of operating accidents at the Solvent Column Pilot Plant (Building 3503). One accident involved a leaking waste tank discharge line. In another incident, the thorium waste tank overflowed and contaminated the surrounding soil and groundwater. The groundwater surrounding these tanks was pumped to the settling basin.

Contamination of Surfaces and Soil from a 1959 Explosion in Building 3019 Cell (SWMU 1.6)

On November 20, 1959, a nonnuclear explosion involving an evaporator occurred in a shielded cell in Building 3019. Plutonium from the cell contaminated areas in Building 3019 and nearby streets and structures. Fallout of the radioactivity was reported as rapid, and only a small fraction of the ORNL area was contaminated.

Decontamination actions included multilayer painting, paving streets, reroofing buildings, and removing and replacing contaminated soils. An estimated 600 mg of plutonium-239 and plutonium-240 was released. It is reported that most of the contamination was removed during the decontamination.

Contamination at Base of Building 3019 Stack (SWMU 1.7)

The nature and source of the contamination at this site, also called the "3019 Hot Bank," is not well defined. Sources of contamination may be LLW line leaks or stack emissions. Contamination measured at the site during August 1985 includes cobalt-60, cesium-137, cadmium-244, americium-241, plutonium-238, and plutonium-239. Gross alpha and beta concentrations observed in soil samples at the site range up to 1.7×10^5 and 4.1×10^5 Bq/kg, respectively.

Graphite Reactor Storage Canal Overflow (SWMU 1.8)

This canal was used to store and transfer irradiated fuel slugs and targets from the Graphite Reactor to the 3019 fuel reprocessing pilot plant. Although no data or written reports exist regarding an overflow from the canal, notes accompanying an ORNL drawing mention that an overflow may have occurred. If a leak did occur, it would be anticipated that contaminants present would be fission activation products leaking from the fuel slugs and irradiation targets.

Oak Ridge Research Reactor Decay Tank Rupture Site (SWMU 1.9)

In 1974 a leak was reported in the 11,000-gal underground decay tank for the Oak Ridge Research Reactor. Primary coolant water was being released at a rate of 1.5 gal/min. The tank was removed, repaired, and replaced during April 1974. During the excavation and repair, radiation levels up to 2 R/h and transferable contamination up to 35 mR/h at 1 inch were reported. There are no records of the residual radioactivity levels remaining at the site after repairs were completed.

3517 Filter Pit (Fission Product Development Laboratory - Building 3517) (SWMU 1.20)

The filter pit east of Building 3517 was put in service in 1958 to filter building air exhaust from the Fission Product Development Laboratory (FPDL). The stainless steel roughing filters were acid-backwashed, and the leakage from this operation has contaminated the filter pit. During recent excavations at the site, large quantities of contaminated soil were removed. The principal contaminants are cesium-137 and strontium-90.

FPDL LLW Transfer Line (SWMU 1.21)

The line was installed in 1958 and taken out of service in 1978. Wastes are currently transferred to a collection header on the west side of the South Tank Farm. No leaks have been reported. The inactive line is reported to be contaminated with cesium-137 and strontium-90 but no inventory information is available.

Isotopes Ductwork/Building 3110 Filter House (SWMU 1.22)

This filter house serves the cell ventilation air exhaust in the isotopes area. A floor drain in Building 3110 collects groundwater and transports it to Tank WC-10. Groundwater leakage into the underground air duct system also accumulates and is collected in a sump for transfer to the process waste system. This site has been removed from service.

3.2.2.2 Chemical Leaks and Spills. A brief description of each of the chemical leaks and spills is provided below.

Mercury-Contaminated Soil - Building 3503 (SWMU 1.1)

During the 1950s and early 1960s, substantial quantities of mercury were used in the spent fuel reprocessing program known as PUREX. No information exists on the quantity of possible losses. Analysis of soil samples collected from various locations around Building 3503 has indicated quantities of mercury ranging from 0.8 to 25 ppm.

Mercury-Contaminated Soil - Building 3592 (SWMU 1.2)

During 1956, supporting equipment development work was performed in Building 3592 in conjunction with the research activity on lithium separation. Over a period of about 2 months, more than 60,000 lb of mercury was used. No record of the amounts lost through spills is available; however, operating personnel have estimated that a total of 2000 to 3000 lb of mercury was lost through spills and leaks. Analysis of soil samples taken in 1983 from various locations around 3592 showed mercury concentrations ranging from 4.1 to 320 ppm.

Mercury-Contaminated Soil - Building 4501 (SWMU 1.3)

For about 6 months during 1954, ton quantities of mercury were used at Building 4501 for the operation of a small pilot plant for lithium separation (OREX process). Spills did occur. During a spill the visible mercury was cleaned up, but some escaped into cracks in the concrete floor. Currently the building is used as a high-level radiochemistry laboratory. Analyses of soil samples collected in 1983 from various locations around Building 4501 indicated concentrations of mercury ranging from 0.05 to 465 ppm.

Mercury-Contaminated Soil - Building 4508 (SWMU 1.4)

Although research activities in Building 4508 are reported to have used inventories of less than 100 lb of mercury, there is no information available to indicate that a mercury spill has occurred. No soil sampling has been conducted around Building 4508.

3.2.3 Ponds and Impoundments

Nine ponds or impoundments identified in WAG 1 have been designated as SWMUs. Of these sites, four contain process wastes and two are ponds that have been taken out of service and backfilled. The remaining three sites include the two aerated lagoons formerly used for treatment of ORNL sewage and the coal pile runoff collection basin. More detailed information on the ORNL ponds can be obtained from Taylor (1986), Francis and Stansfield (1986), Stansfield and Francis (1986a and 1986b), Kitchings and Owenby (1986), and Braunstein et al. (1984). A brief description of each of the ponds and impoundments is provided below.

Waste Holding Basin (SWMU 1.12)

This basin (3513) was constructed during the 1940s as part of an early waste treatment scheme that involved neutralizing and precipitating sludges in the Gunite tanks, then decanting the supernatant to the basin. The supernatant was diluted with process wastewater and, after additional settling, was released to WOC. The capacity of the basin is approximately 1.6 million gal.

After construction of the PWTP (Building 3518) in 1957, the basin was used as a settling basin for pretreated waste before release to WOC. The basin was removed from service in 1976 when the new PWTP (3544) was completed.

Equalization Basin (SWMU 1.13)

This basin (3524) serves to equalize flow for the PWTP. As originally constructed in the 1940s, two 300,000-gal ponds were to be used to provide emergency holdup of LLW. When the original PWTP (3518) was completed in 1957, the earthen dike between the two ponds was removed, creating a 600,000 gal flow-equalization basin. In 1961 the capacity of the basin was increased to 1 million gal.

Process Waste Ponds 3539 and 3540 (SWMUs 1.14 and 1.15)

These ponds were constructed to hold process waste generated at the 4500 complex. Pond contents are sampled before a decision is made to treat the waste or discharge it directly to WOC. The capacity of each pond is 150,000 gal.

Decommissioned Waste Holding Basin (SWMU 1.11)

This basin (3512) was constructed in the 1940s as part of the emergency holdup and settling basin for process waste. The reported capacity of the basin, which has been filled in, was 30,000 gal.

Low Intensity Test Reactor (LITR) Pond (SWMU 1.19)

Two retention ponds were constructed at the LITR to retain the primary coolant (water) when the reactor pool was drained. Little information is available on the characteristics of the waste. However, it was reported to be mainly sodium-24 (half-life of 15 h). Each pond was 40 ft by 8 ft and had a capacity of 18,000 gal. Following radioactive decay, the supernatant from the pond was discharged to Fifth Creek. A radiological study of the site in 1985 showed that average activities of strontium-90, plutonium-238, and plutonium-239 in the soil were higher than background (Boegly et al., 1987). There also was some contamination due to cesium-137 and cobalt-60. The radionuclide inventory was estimated at 20 mCi of cesium-137, 1 mCi of strontium-90, and 100 uCi of plutonium-239. The ponds have been filled in and grassed.

Sewage Aeration Ponds 2543 and 2544 (SWMUs 1.16 and 1.17)

These ponds were operated in series as aeration lagoons for treating the sanitary sewage generated within ORNL. Each lagoon has a capacity of about 1 million gal. The ponds were constructed in 1974 and were used until the new sewage treatment plant was completed.

The ponds are now used as an equalization basin for the package sewage treatment plant and are available for holdup and temporary treatment of sewage if the main sewage treatment plant is out of service.

Coal Pile Settling Basin (SWMU 1.18)

This basin (2545) was constructed in 1978 as part of the ORNL steam plant's conversion to coal from oil and gas. The basin is located southwest of the coal pile. Following neutralization of the runoff and sedimentation in the basin, the clarified effluent is released to WOC. Capacity of the basin is approximately 300,000 gal.

3.2.4 Waste Treatment Facilities

Two sites have been categorized as waste treatment facilities, and a brief description of each is presented below.

Waste Evaporator Facility 3506 (SWMU 1.62)

The Waste Evaporator Facility 3506 received the LLW liquid waste streams from ORNL laboratories and other processing areas during the 1950s for concentration prior to final disposition by shale fracture techniques. This activity was suspended when the presently active evaporator facility (Building 2531) was brought on-line. Subsequent installations of experimental equipment were used to develop fission-product purification processes and demonstrate contamination waste incineration. The facility consists of a stainless steel-lined, reinforced concrete cell with underground piping, valve pit, and an attached wood-framed operating area. The building dimensions are approximately 22 ft by 28 ft by 8 ft high. The evaporator facility is located on the west side of the south tank farm (Site 3507). The waste evaporator was decontaminated prior to its use as an incinerator facility. Hence, the building now contains only low levels of contamination, primarily associated with the valve pit, piping, and some surface contamination. The radionuclides of concern are expected to be cesium-137 and strontium-90, in less than curie quantities.

Storage Canal and Dissolver Pit 3505 (SWMU 1.63)

The Storage Canal and Dissolver Pit 3505, part of the MRF, was a pilot- and small-scale production nuclear fuel reprocessing plant used for the processing of various waste solutions, scrap, and miscellaneous fuel elements for the recovery of uranium, plutonium, neptunium, and americium. The facility was shut down in 1960, after some 25 different processing campaigns, due to the lack of secondary containment. The MRF is a one-story metal-sided building, approximately 90 ft long by 70 ft wide by 24 ft high and is located south of the south tank farm. The items of processing equipment that remain are contained in seven concrete or concrete-block cells, which are secured and maintained under negative pressure, with ventilation through HEPA filters. The building also houses a makeup area, offices, storage area, a control room, and an active shop. A below-grade concrete dissolver pit and fuel-handling canal are located inside and adjacent to the building, respectively, both with controlled access. Two associated underground, stainless steel storage tanks [W-19 and W-20 (SWMUs 1.56a and b)] are located some 50 ft east of the building.

The building structure is basically sound although gradually deteriorating with time. The major structural deficiencies are associated with the roof, which is of light construction. The process cells still contain a variety of tanks, process columns, and assorted instrumentation. The facility has few special features for contamination control, although it does have an upgraded cell ventilation system. The canal and dissolver pit have been stabilized and placed in a monitored, controlled standby condition under the surplus facility program.

The process cells are internally contaminated, primarily along lower walls and inside process equipment. The majority of this activity is due to long-lived radionuclide surface contamination present.

Beginning in FY 1984, decommissioning operations were undertaken at the MRF. These activities consist of process equipment removal, cell, canal, and dissolver pit decontamination, and associated facility modifications leading toward potential reuse of the building. The initial decontamination operations are planned for FY 1984 through FY 1989, with the potential for additional facility dismantlement beyond that time. During this project phase, routine maintenance and surveillance must still be continued.

3.2.5 Solid Waste Storage Areas

During early operations at ORNL (1943-1946), radioactive solid wastes were buried at two sites within the WAG 1 boundary: SWSA 1 and SWSA 2. An additional disposal site, the Former Waste Pile Area, is also within WAG 1.

Operation of the two SWSAs is described in Webster (1976) and Coobs and Gissel (1986). Brief descriptions of the SWSAs and the Former Waste Pile Area are provided below.

SWSA 1 (SWMU 1.46)

SWSA 1 was operated for a short time in 1944 to dispose of contaminated solid wastes produced during routine laboratory operations. Disposal was conducted in trenches using a technique similar to a sanitary landfill operation. No records exist of the amount or composition of waste buried.

SWSA 2 (SWMU 1.47)

Disposal operations in SWSA 2 began in 1944 and were discontinued in 1946. when it was later determined that the presence of SWSA 2 was not compatible with long-range land use planning at ORNL, the wastes and some of the surrounding soil were removed and reburied in SWSA 3. The site was backfilled with clean soil and contoured to be compatible with the general area. No records exist of the amount of waste buried or its composition.

Former Waste Pile Area (SWMU 1.58)

The Former Waste Pile Area is located to the south of the site of the nonradiological wastewater treatment facility. The exact extent of the area is unknown; but on the basis of old ORNL photographs, it appears to occupy 15 to 20 acres. Interviews with ORNL staff indicate that the site was used as both a soil borrow area and a disposal area for construction debris (Nix, 1989). Identification of particular wastes has not been undertaken, but an excavation for installation of a transfer pipeline uncovered numerous metal and glass containers, transite, and miscellaneous metal piping and scrap.

3.2.6 Summary of Contaminant Source Term Data

The initial WAG 1 RI Plan included data on the known contaminants within WAG 1. At that time, the contents of the inactive tanks had not been sampled, so the full array of contaminants had not been identified. Table 3-10b is a matrix of contaminant source term data as taken from both the original WAG 1 RI Plan and this revision. With the exception of the inactive tanks, data on the organic and inorganic compounds is unavailable. The tank data, however, is considered by the BNI Team to be representative of the range of contaminants present in the WAG.

TABLE 3-10b

CONTAMINANT SOURCE TERM DATA

Contaminant Source	Radionuclides Alpha	Beta	Gamma	Organics (Volatiles and Semivolatiles)	Inorganics	Mercury
Soils						
o 3019 Area	X[a]	X	X	•[b]	•	•
o 3085 Area	X	X	•	•	•	•
o 3000 Area	X	X	X	•	•	X
o 3500 Area	X	X	X	•	•	•
o Process Area	X	X	X	•	•	•
o Hg Areas						X
Tanks						
o Inactive	X	X	X	X	X	X
o Active	X	X	X	•	•	•
Impoundments						
o Radiological Processes	X	X	X	X	X	X
o Chemical/ Sewage	•	X	•	•	•	•
Solid Waste Storage Areas	X	X	X	•	•	•

[a] An "X" in the contaminant column indicates the presence of the contaminant in the appropriate area.

[b] A dot (•) in the contaminant column represents suspected hazardous contaminants for which no data exists; but because the wastes were LLW in nature, they are suspected of being present.

Source: Grimsby (1986a; 1986b), Boegly et al. (1987), and Autrey et al. (1989).

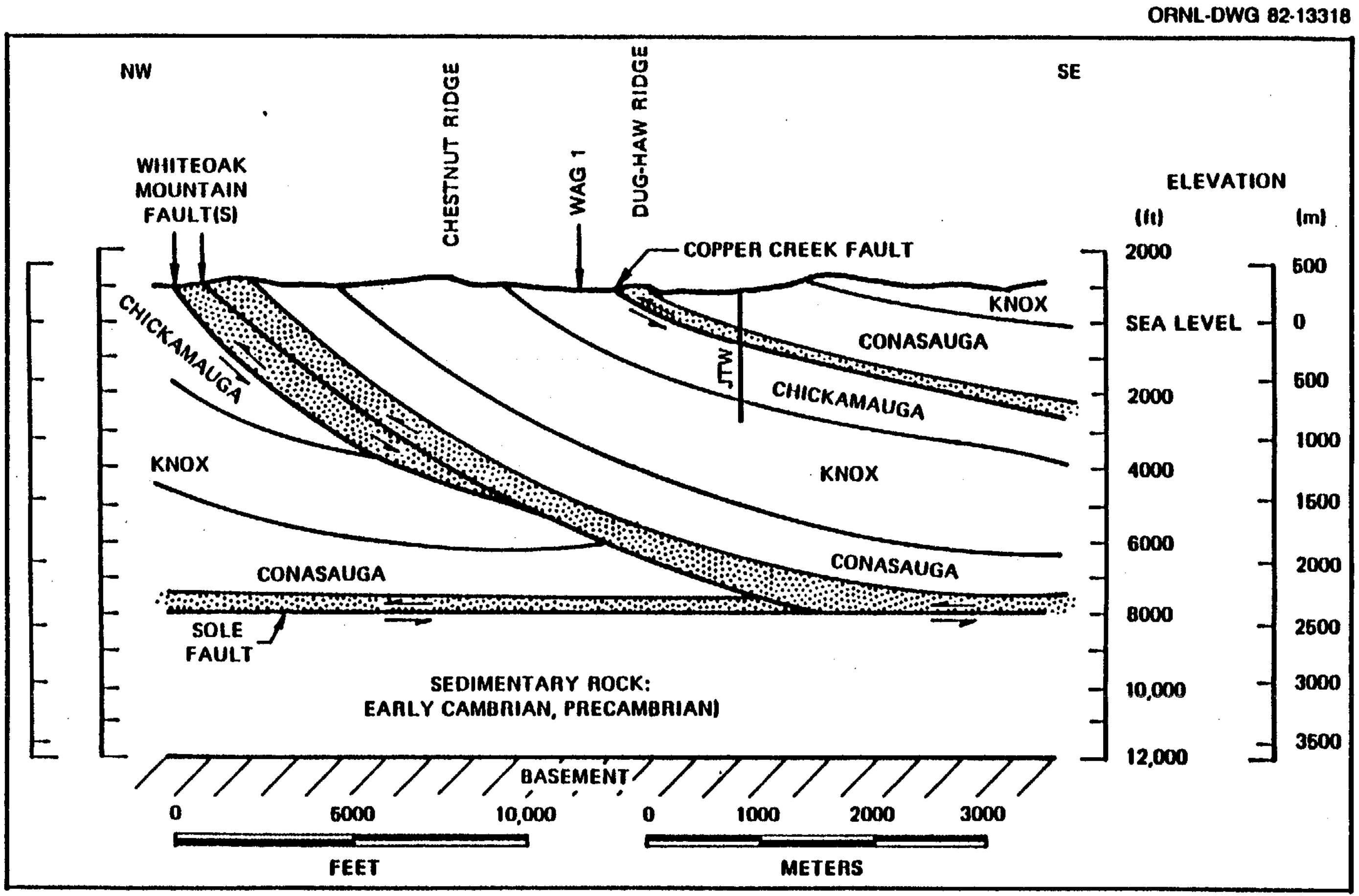
3.3 WAG 1 SITE DESCRIPTION AND CHARACTERIZATION

3.3.1 Site Environmental Setting

3.3.1.1 Geology. WAG 1 lies within Bethel Valley between Chestnut Ridge and Haw Ridge (Figure 3-7). It is underlain by the limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group. Stockdale (1951) summarized the mappable units of the Chickamauga Group as shown in Table 3-11 and as mapped in Figure 3-8. Figure 3-9 provides a generalized geologic cross section through the Main Plant Area showing the approximate relative positions of Stockdale's units C-H and selected WAG 1 SWMUs. Stockdale (1951) reports that the average strike of the units of the Chickamauga Group in the vicinity of WAG 1, 56^{o}E, is slightly different from that of the regional trend of Bethel Valley, 58^{o}E. The dip of these units is to the southeast, commonly between 30^{o} and 40^{o}.

Stockdale describes the upper limestone units of the Chickamauga Group as being tightly cemented and compact with the exception of several small solution channels, typically around 1-in. in diameter, but up to as large as 1 ft. McMaster and Waller (1965) confirmed the categorization of Stockdale on the basis of a geologic and soil study of the WOC basin.

In 1985, five boreholes, each approximately 400 ft deep, were completed in a northwest-southeast transect along the east side of Fifth Creek. This study provided representative cases from each of Units B through G of the Chickamauga Group (Boegly et al., 1987). It is reported that geophysical logs obtained during that study indicated that the rock is tightly cemented and competent. Fractures often appeared to be remineralized with calcite, with some exhibiting signs of motion.



SOURCE: BOEGLY et al., 1987

FIGURE 3-7
GEOLOGIC CROSS-SECTION BENEATH WAG 1
THROUGH THE OAK RIDGE RESERVATION

Table 3-11

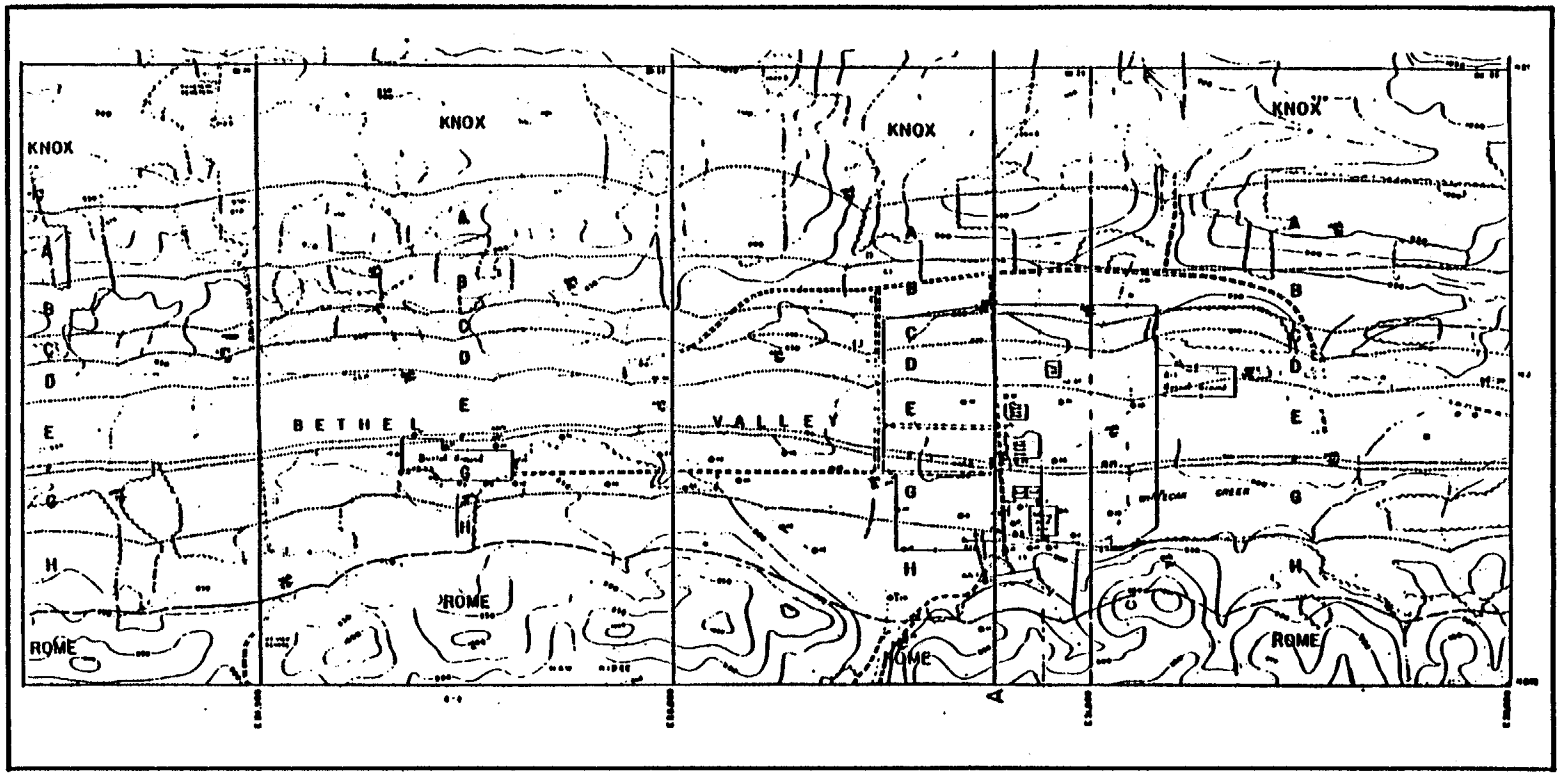
STRATIGRAPHIC DESCRIPTION OF THE ORNL AREA

Unit	Rock Description	Thickness (m)
H	Siltstone; calcareous; gray, olive, maroon; with shaly partings and thin limestone lenses	25.91
	Limestone of varied types; gray, olive-gray, buff drab; mostly thin-bedded; with argillaceous partings; weathers to shaly appearance; with fossiliferous zones	54.86
	Limestone; argillaceous (calcareous siltstone); gray, olive-gray, "pinkish" maroon; even-bedded, with shale partings	10.67
G	Limestone of varied types; dark gray to brownish gray; mostly modular with abundant black irregular clay partings; dense to medium-grained; mostly thin-bedded, partly massive, with shale partings; weathers to a lighter-colored shaly or "modular" appearance; with some fossiliferous horizons; mostly covered in lowlands	91.44
F	Siltstone; calcareous, alternating with shale; olive-gray to maroon; even-bedded; laminated; weathers to a red shaly appearance; produces a slight rise in topography; a very distinctive unit	7.62
E	Limestone; mostly gray to drab, partly pinkish maroon, mottled; brittle, thin-bedded to massive; with shaly partings	18.29
	Limestone similar to "G" above; mostly covered in lowlands	67.06
	Calcareous shale and argillaceous limestone; gray to buff; in alternating thin even beds; yielding small roundish slabs upon weathering, with yellow-buff color	13.72
	Limestone of varied types; gray, mostly argillaceous and modular; in thin irregular beds with shale partings; abundant fossils	16.76

Table 3-11 (Continued)

Unit	Rock Description	Thickness (m)
D	Limestone and chert; limestone is gray to olive-gray; in part modular, shaly, and thin bedded; in part massive; with abundant chert in thin, even bands, breaking into angular fragments upon weathering; produces a chain of low hills	48.77
C.	Shale; calcareous; olive-gray to light maroon; fissile; even-laminated	3.05
	Limestone of varied types; gray; fine to coarse grained, partly crystalline, partly modular; mostly massive; with occasional patches of chert; partly fossiliferous; "quarry beds"	32.00
B	Siltstone, in even beds up to 2 ft thick, laminated, alternating with calcareous shale; olive-gray, buff, maroon; some limestone, nonresistant; more shale at base	65.53
A	Limestone of varied types; dark gray to buff; with shale partings; with gray to black chert in nodules and lenses	24.38
	Chert; thin-bedded, with shaly partings	4.57
	Siltstone calcareous; olive-gray to maroon; weathers to shaly appearance	9.14
	Siltstone and chert, in alternating beds; siltstone is calcareous, gray, olive, maroon; weathers to shaly appearance; with abundant granular chert in even beds up to 6 in. thick, breaking into angular blocks upon weathering	27.43
	Limestone; mostly covered	7.62
	Total thickness	528.82

Source: Stockdale (1951).



SOURCE: STOCKDALE (1951)

	PLATE 3 (82-22)	PLATE 4 (82-23)	PLATE 5 (82-24)	PLATE 6 (82-25)
	PLATE 7 (82-27)	PLATE 8 (82)28)	PLATE 9 (82-29)	PLATE 10 (82-30)

INDEX OF LARGE-SCALE SHEETS
USED FOR FIELD MAPPING

LEGEND

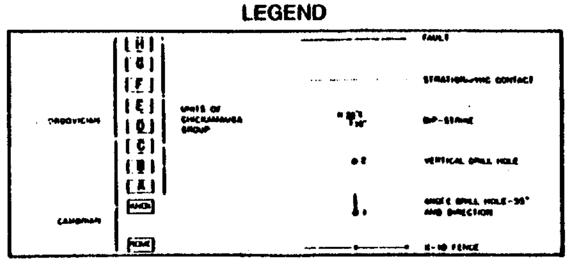


PLATE 2
GEOLOGIC MAP OF THE OAK
RIDGE NATIONAL LABORATORY
(X-10) AREA

FIGURE 3-8
GEOLOGIC MAP OF THE ORNL AREA

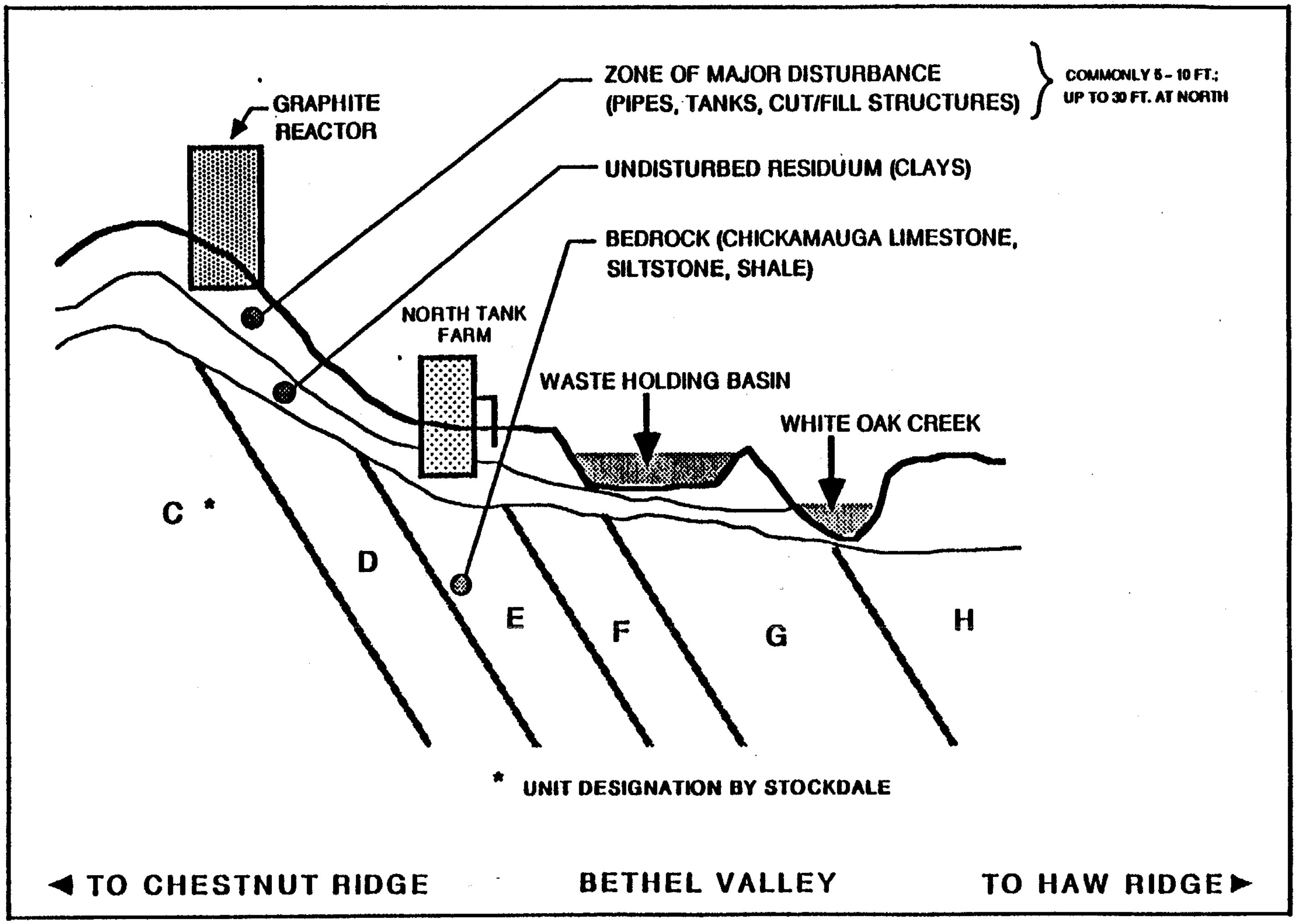


FIGURE 3-9
GEOLOGIC CROSS-SECTION THROUGH MAIN PLANT AREA

C23/wag1-13

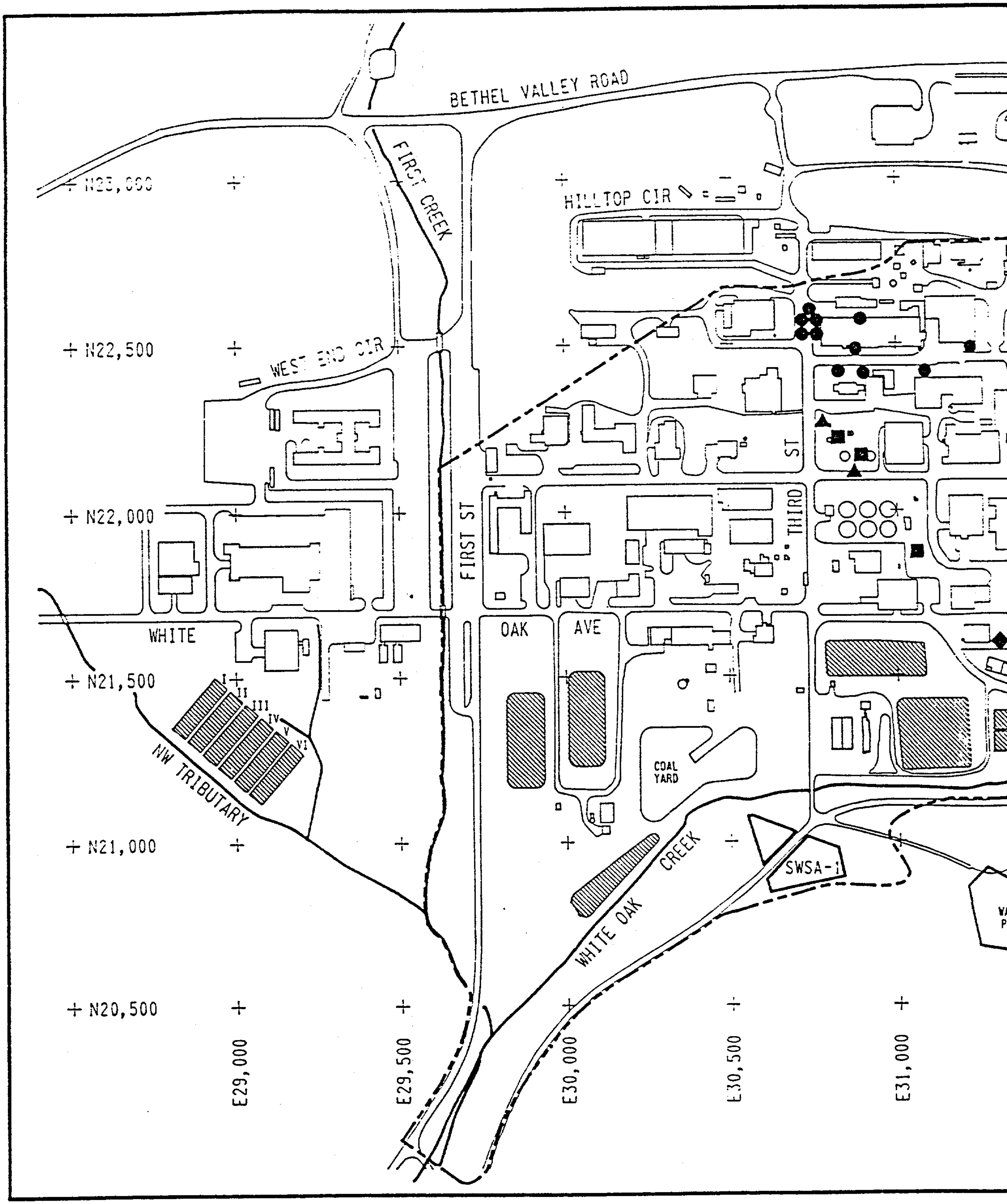
3.3.1.2 Soils. Generally, soil thicknesses at the site range from 1 to 25 ft. The deepest soils are found along the low ridge that crosses the northern portion of the site, near the Graphite Reactor. The thinnest soils are found in the southern portion of the site, near the surface impoundments and WOC.

Generally, the natural soils on WAG 1 are produced by the in-place weathering of the Chickamauga bedrock. The soils typically consist of yellow, light reddish-orange, or red clay of medium stiffness containing variable quantities of chert, siltstone, and limestone fragments. The mineralogy of native soils reflects composition of the underlying bedrock.

The soils at the site have been highly disturbed by construction activities. Reworked native soils and nonnative, imported fill materials have been placed in pipe trenches, under foundations and slabs, as backfill around buildings, and in other excavations throughout the site. This anthropogenic zone extends from the surface to various depths throughout the site, frequently extending to the bedrock surface, as is the case at SWMU 1.26 (South Tank Farm). The anthropogenic zone is so complex that complete characterization of all material types and their distribution is not considered to be cost effective and, for practical purposes, is infeasible.

Some surface soil sampling has been conducted within the confines of WAG 1 (Figure 3-9a). Generally, in specific areas, such as leak sites, spill areas, and burial grounds within the WAG boundary. In 1976 and 1977, SWSA 2 was considered as a possible location for the Energy Systems Research Laboratory (ESRL), and soil core samples were collected to examine the subsurface soils for radioactive contamination (Oakes and Shank, 1977). A total of 25 cores, ranging from 4 to 9 ft deep, were collected and analyzed for alpha-, beta-, and gamma-emitting isotopes. The soil borings were collected in two phases. During the first phase, 13 samples were collected. Each sample was homogenized and a representative portion submitted for analyses. During the second phase, 12 samples were collected and separated into three samples to obtain a depth profile. Each third of the core sample was then submitted for analyses. The results from the 13 homogenized samples indicated uranium and plutonium levels slightly higher than samples collected near perimeter air monitoring stations. The samples collected for depth profile analyses indicated higher levels of radioisotopes (Cs-123, K-40, Ra-226, and Th-232) in the shallower samples. The average core concentrations were found to be less than those from background samples. The ranges of radionuclide concentrations observed is provided in Table 3-11a.

Soils were collected as a part of preliminary characterization of 15 inactive waste tanks. A summary of these data extracted from Huang et al. (1984a) is presented in Table 3-12.



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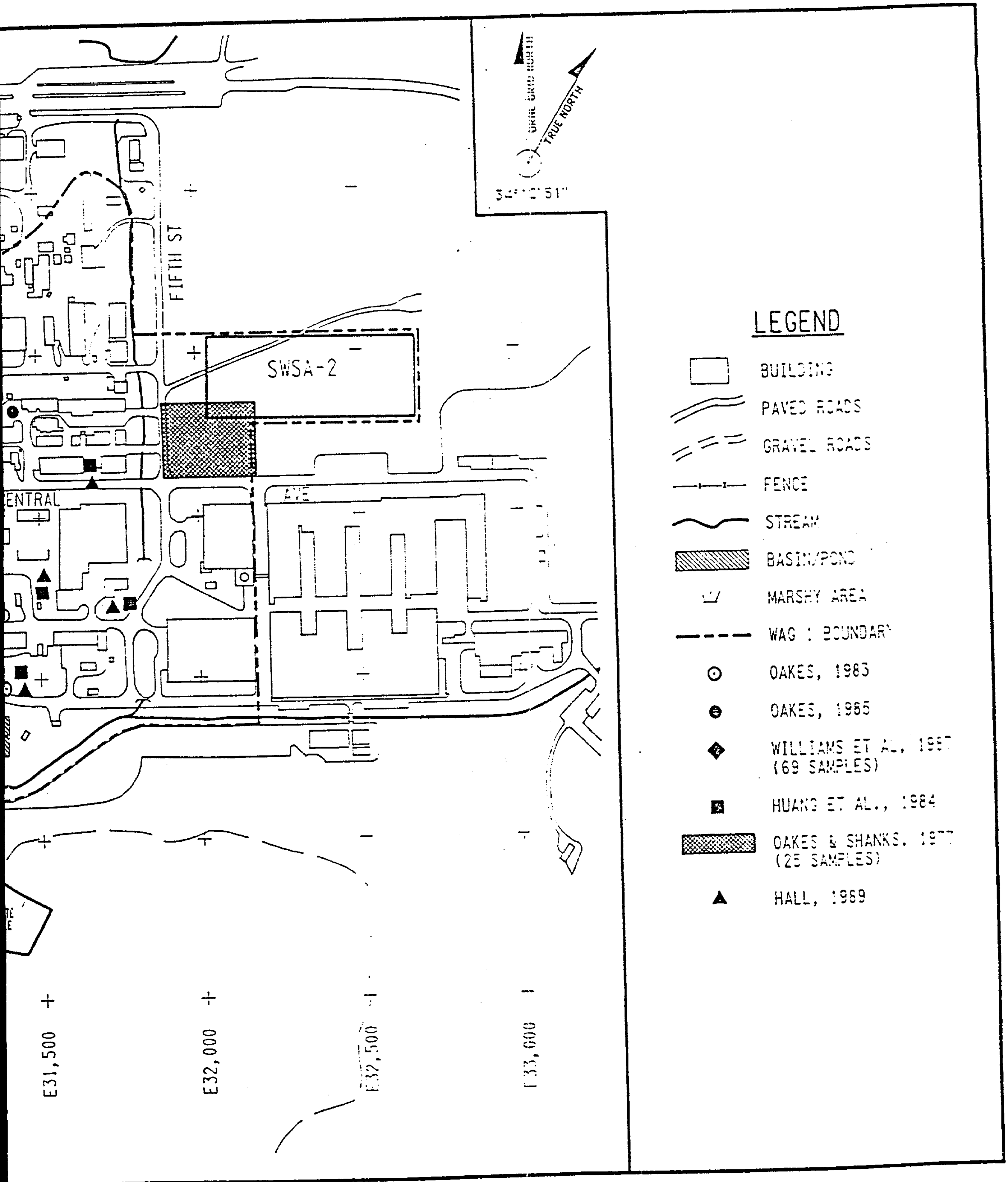

FIGURE 3-9A
APPROXIMATE LOCATIONS OF SOIL AND DRY WELL (GROUNDWATER) SAMPLING SITES IN WAG 1

(REV.1)

TABLE 3-11a

RANGES OF RADIONUCLIDE CONCENTRATIONS IN SOIL AT WAG 1

Parameter	Concentration Range
SWSA 2[a]	pCi/g
U	ND - 1.1
Th	0.093 - 0.88
Sr-90	<0.17 - 3.4
Pu	0.020 - 0.14
Cs-137	ND - 1.9
K-40	ND - 16
Ra-226	0.4 - 1.1
Th-232	0.10 - 1.6
Pu-239	<0.00045 - 0.22
Pu-238	<0.00045 - 0.0059
3019/3028 Leak Areas[b]	Bq/kg
Gross alpha	150 - 338,000
Gross beta	<20 - 17,300,000
Sr-90	10 - 771,000
Cs-137	20 - 63,000
Co-60	<1 - 2×10^8
3503 Storage Pad Area[c]	pCi/g
Am-241	0.11 - 0.58
Co-57	0.055
Co-60	0.077 - 30
Cr-51	3.0 - 34
Cs-134	9.4 - 230
Cs-137	1.6 - 180,000
Eu-152	0.34 - 71
K-40	1.2 - 280
Mn-54	0.023 - 5.9
Ra-226	0.48 - 1.5
Ra-228	0.85 - 3800
Th-232	0.81 - 3800
Th-234	0.61 - 750
Cm-244	0.00054 - 1.1
Pu-238	0.13 - 700
Pu-239	0.54 - 68
Sr-90	1.9 - 110

TABLE 3-11a (Continued)

Parameter	Concentration Range
Tank WC-1 Area[d]	Bq/kg
Gross alpha	270±200 - 300±210
Gross beta	110±100 - 4,400±100
Co-60	<2 - 54±5
Cs-137	3.4±2 - 1,100±100
K-40	190±70 - 340±40
Tank WC-15 Area[d]	Bq/kg
Gross alpha	230±160 - 830±330
Gross beta	1,000±100 - 1,600±100
Co-60	<2
Cs-137	<2 - 5±2.2
K-40	680±80 - 880±50
Equalization Basin 3524 Area[e]	Bq/kg
Gross alpha	180±200 - 19,000±3,000
Gross beta	830±200 - 930,000±10,000
Co-60	<2 - 2,800±100
Cs-137	9.1±3 - 470,000±10,000
K-40	140±50 - 1,100±100
Cs-134	14±7 - 40±20
Eu-152	<50±10 - 870±30
Eu-154	65±7 - 270±20
Eu-155	17±10 - 93±50

Source: [a]Oakes and Shanks (1977).
[b]Oakes (1985).
[c]Williams et al. (1987).
[d]Autrey (1989).
[e]Williams (1989).

TABLE 3-12

A SUMMARY OF THE RADIOLOGICAL CHARACTERISTICS OF EACH TANK SITE

Tank site	Tank depth [top (m)/bottom (m)]	Radionuclide	Core number	Depth of maximum concentration (m)	Number of samples from core	Concentration (Bq/g) Mean	Minimum	Maximum
NTF	2.7/4.9	^{60}Co	19	4.3-4.8	4	180	0.01	700
			6	3.6-4.3	2	0.74	0.01	1.5
			2	4.8-5.4	2	0.46	0.03	0.89
			7	2.4-3.0	2	0.17	0.01	0.34
			10	0-0.3	1	0.07	0.07	0.07
			12	0.3-0.6.	1	0.07	0.07	0.07
			24	4.3-4.8	3	0.05	0.004	0.08
			3	0-0.3	1	0.02	0.02	0.02
			25	0-0.3	1	0.01	0.01	0.01
			8	1.8-2.4	1	0.01	0.01	0.0
		^{137}Cs	19	4.3-4.8	7	2,400	0.04	17,000
			7	0.6-1.2	9	290	0.33	1,300
			23	2.4-3.0	6	46	0.26	180
			17	0-0.3	3	6.2	0.06	19
			3	0-0.3	5	1.6	0.004	4.0
			13	1.8-2.4	10	1.4	0.05	3.1
			12	0.3-0.6	3	1.2	0.01	2.7
			25	0-0.3	4	0.95	0.06	2.8
			21	0.3-0.6	4	0.77	0.004	2.5
			16	0-0.3	10	0.65	0.09	2.9
			15	0-0.3	3	0.47	0.06	1.0
			6	3.6-4.3	3	0.34	0.01	0.93
			8	0-0.3	3	0.32	0.01	0.85
			18	0.6-1.2	3	0.31	0.22	0.41
			1	0-0.3	6	0.30	0.004	0.85
			24	0.6-1.2	8	0.24	0.05	0.70
			9	0-0.3	5	0.24	0.01	0.94
			10	0-0.3	3	0.23	0.004	0.67
			4	4.3-4.8	3	0.21	0.19	0.25
			2	0-0.3	4	0.18	0.03	0.44
		^{90}Sr	19	4.3-4.8	2	1,300	0.38	2,500
			2	4.3-4.8	2	900	0.26	1,800
			25	4.3-4.8	2	46	0.33	91
			6	3.6-4.3	1	43	43	43
			24	4.8-5.4	2	19	16	21
			7	1.2-1.8	4	17	0.35	48
			23	3.0-3.6	1	5.8	5.8	5.8
			17	0.3-0.6	1	0.95	0.95	0.95
			9	0-0.3	1	0.64	0.64	0.64
			10	0-0.3	1	0.62	0.62	0.62

TABLE 3-12, Continued

Tank site	Tank depth [top (m)/bottom (m)]	Radionuclide	Core number	Depth of maximum concentration (m)	Number of samples from core	Concentration (Bq/g)		
						Mean	Minimum	Maximum
			3	0.6-1.2	2	0.46	0.38	0.53
			13	0.3-0.6	5	0.32	0.09	0.57
			16	0-0.3	2	0.32	0.28	0.35
			4	0-0.3	1	0.30	0.30	0.30
			18	0-0.3	1	0.29	0.29	0.29
			12	0.3-0.6	1	0.24	0.24	0.24
			21	0.3-0.6	1	0.18	0.18	0.18
TH-4		^{60}Co	2	0.6-1.2	3	0.01	0.002	0.01
		^{137}Cs	2	0.6-1.2	4	0.41	0.08	1.1
			1	3.6-4.3	3	0.08	0.01	0.14
			3	0.3-0.6	3	0.05	0.04	0.07
		^{90}Sr	1	0.3-0.6	2	0.24	0.11	0.36
TH-1,2,3	3.1/4.3	^{60}Co	6	4.3-4.8	1	0.31	0.31	0.31
			1	3.0-3.6	4	0.03	0.01	0.09
			7	3.6-4.3	1	0.03	0.03	0.03
			2	3.6-4.3	3	0.01	0.01	0.01
			3	1.8-2.4	1	0.01	0.01	0.01
		^{137}Cs	6	4.3-4.8	3	94	0.22	280
			1	3.0-3.6	8	7.6	0.03	22
			2	1.8-2.4	6	4.7	0.48	11
			7	3.6-4.3	1	2.0	2.0	2.0
			3	1.2-1.8	4	0.17	0.05	0.26
		^{90}Sr	2	1.2-1.8	3	70	5.9	170
			1	1.8-2.4	7	4.5	0.32	14
			6	4.3-4.8	2	4.0	0.02	7.9
			7	3.6-4.3	1	0.56	0.56	0.56
			3	2.4-3.0	1	0.18	0.18	0.18
W-11	1.8/3.7	^{60}Co	3	3.6-4.3	3	0.15	0.01	0.44
			5	3.6-4.3	1	0.07	0.07	0.07
			2	0.6-1.2	3	0.01	0.01	0.02
		^{137}Cs	2	3.6-4.3	8	17	0.30	110
			4	0-0.3	3	6.0	0.52	16
			3	1.2-1.8	8	6.0	0.02	25
			1	0.3-0.6	5	1.7	0.70	2.6
			5	0.3-0.6	8	0.36	0.01	1.5

TABLE 3-12, Continued

Tank site	Tank depth [top (m)/bottom (m)]	Radionuclide	Core number	Depth of maximum concentration (m)	Number of samples from core	Concentration (Bq/g) Mean	Minimum	Maximum
		^{90}Sr	4	0.3-0.6	3	39	24	54
			2	3.6-4.3	4	19	2.6	42
			3	0.3-0.6	7	18	0.20	34
			1	0.3-0.6	4	6.2	2.2	12
			5	0-0.3	3	2.8	0.93	6.0
WC-1	3.1/5.0	^{60}Co	3	3.6-4.3	10	7.6	0.02	22
			1	4.8-5.4	9	4.6	0.02	16
			4	2.4-3.0	6	0.87	0.004	2.0
			2	3.0-3.6	4	0.20	0.02	0.67
		^{137}Cs	3	1.8-2.4	10	8.8	0.44	44
			1	0.3-0.6	9	0.64	0.04	1.6
			2	0-0.3	6	0.29	0.04	0.63
			2	1.8-2.4	6	0.29	0.04	0.63
			4	0-0.3	6	0.13	0.02	0.41
		^{90}Sr	1	1.8-2.4	4	110	0.14	200
			2	3.0-3.6	2	76	2.2	150
			3	3.6-4.3	8	45	0.30	190
			4	1.8-2.4	3	6.7	0.37	13
WC-15,17	3.4/5.5	^{241}Am	4	3.0-3.6	5	1.7	0.011	3.9
			6	0.6-1.2	2	0.087	0.074	0.10
			1	3.6-4.3	1	0.0069	0.0069	0.0069
			5	3.0-3.6	1	0.0008	0.0008	0.0008
		^{244}Cm	4	3.0-3.6	5	1.6	0.0059	2.7
			6	3.0-3.6	2	0.70	0.20	1.2
			1	3.6-4.3	1	0.0076	0.0076	0.0076
			5	3.0-3.6	1	0.0009	0.0009	0.0009
		^{134}Cs	6	0.6-1.2	2	0.20	0.074	0.33
		^{137}Cs	4	3.6-4.3	7	3.0	0.022	11
			6	0.6-1.2	6	1.6	0.015	7.4
			1	1.8-2.4	6	0.091	0.056	0.15
			2	0.6-1.2	2	0.09	0.059	0.12
			5	0-0.3	4	0.05	0.019	0.10
			3	0.3-0.6	1	0.031	0.031	0.031
		^{154}Eu	4	3.0-3.6	6	1.7	0.06	4.8
			6	1.2-1.8	1	0.037	0.037	0.037

TABLE 3-12, Continued

Tank site	Tank depth [top (m)/bottom (m)]	Radionuclide	Core number	Depth of maximum concentration (m)	Number of samples from core	Concentration (Bq/g)		
						Mean	Minimum	Maximum
		^{238}Pu	4	4.3-4.8	5	1.6	0.0002	4.2
			6	3.0-3.6	2	0.32	0.20	0.43
			1	3.6-4.3	1	0.0028	0.0028	0.0028
			5	3.0-3.6	1	0.0003	0.0003	0.0003
		^{239}Pu	6	0.6-1.2	2	0.56	0.21	0.90
			4	3.6-4.3	5	0.32	0.0009	0.80
			4	4.3-4.8	5	0.32	0.0009	0.80
			1	3.6-4.3	1	0.0004	0.0004	0.0004
			5	3.0-3.6	1	0.0003	0.0003	0.0003
		^{90}Sr	6	3.0-3.6	2	5.5	0.050	11
			4	3.0-3.6	5	2.3	0.94	4.0
			1	3.6-4.3	1	1.4	1.4	1.4
			2	0.6-1.2	1	0.072	0.072	0.072
			5	3.0-3.6	2	0.050	0.035	0.064

In 1985, a limited soil investigation was performed in response to leaks in the LLW waste transfer line in the 3019 and 3028 areas (Oakes, 1985). Samples were collected at five general areas: 1) the leak site near Building 3074; 2) the area west of Building 3019; 3) the series of four manholes at the southwest corner of Building 3019; 4) the southwest corner of 3001; and 5) the leak site near Building 3028. The highest levels of radioactivity were detected in samples from the leak site near Building 3028. The resultant radionuclide concentration ranges are shown in Table 3-11a.

A limited soil investigation was also performed adjacent to the Storage Pad southwest of Building 3503 (Williams et al., 1987). Soil samples were analyzed for the RCRA hazardous waste characteristics (ignitability, corrosivity, reactivity, and Extraction Procedure Toxicity); all results were below their respective regulatory limits. Sixty-nine samples were collected and analyzed for radionuclides, predominant of which were Cs-137, Pu-238, U-238, Ra-228, Th-232, and Sr-90; the results are summarized in Table 3-11a.

In 1983, soil sampling was performed in the areas surrounding Buildings 4501, 4505, and 4507, and along the bank of Fifth Creek (Oakes, 1983). The highest mercury levels were detected along the bank of Fifth Creek and east of Building 4505 (Oakes, 1983). Soil samples for mercury analyses were also collected south of Building 3592 and southeast of Building 3503 (Oakes, 1983). Results of both samples indicated elevated mercury levels. The mercury concentration ranges observed are provided in Table 3-12a.

3.3.1.3 <u>Surface Water and Sediments</u>. WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. Three tributaries, First Creek, Fifth Creek, and Northwest Tributary, flow through WAG 1. Figure 3-10 shows the location of these streams relative to other streams in the vicinity.

TABLE 3-12a

RANGES OF MERCURY CONCENTRATIONS
IN SOIL AT WAG 1

Area	Concentration Range
4501	0.12 - 465 μg/g
3503	0.8 - 25 ppm
3592	4.1 - 320 ppm

Source: Oakes (1983).

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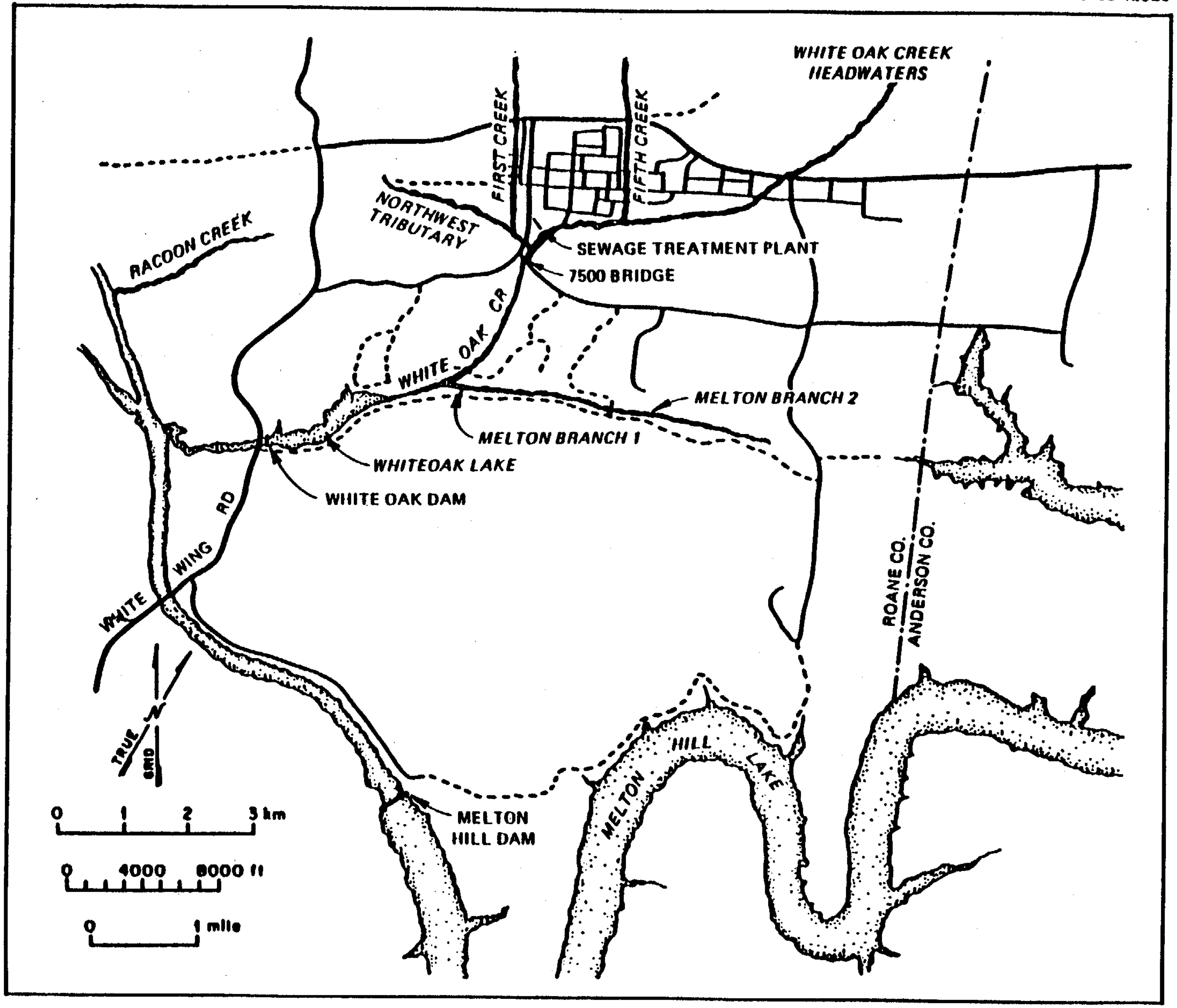


FIGURE 3-10
LOCATION MAP OF ORNL STREAMS

The drainage area of WOC at the WAG 1 boundary is about 2040 acres. The boundaries of the basin extend to the southwest and northeast along Chestnut Ridge and Haw Ridge. The Bethel Valley quandrangle shows a spring as the source of First Creek (Figure 3-11). The spring, located near the foot of Chestnut Ridge, has a potentially large recharge area. First and Fifth creeks collect runoff from the slope of Chestnut Ridge and then course southeast through the plant area to their respective confluence with the Northwest Tributary and WOC. First Creek also collects water from two wells (Figure 3-11) north of Bethel Valley Road. The water is pumped from the wells to a small impoundment on First Creek. (For further discussion of these wells see Subsection 3.3.1.4, Groundwater.)

Recently, USGS has installed a critical flow meter on First Creek (see Figure A7-1, Appendix A.) Discharges have been monitored since February 5, 1987. In the period February 5 to May 28, 1987, the maximum discharge was found to be less than 6 cfs, with most flows less than 1 cfs.

For WOC, for the period June 1949 to September 1955, the maximum discharge was found to be 124 cfs. The average discharge is of the order of 5 cfs.

The Main Plant Area has several major discharges to First, Fifth, and White Oak creeks. These include (1) treated sanitary waste from the sewage treatment plant, (2) cooling tower blowdown, (3) cooling water, (4) process wastewaters, (5) surface runoff from storm sewers, (6) LLW collection and treatment system waters, and (7) demineralizer regenerant waste.

The storm sewer system collects area runoff and water from roof drains, storm drains, and parking lot drains. Sampling of the outfalls indicates that there may also be process line leakage, building drain leakage, and seepage from previous spills entering the system, as well as leakage resulting from improper connections

ORNL-DWG 1239

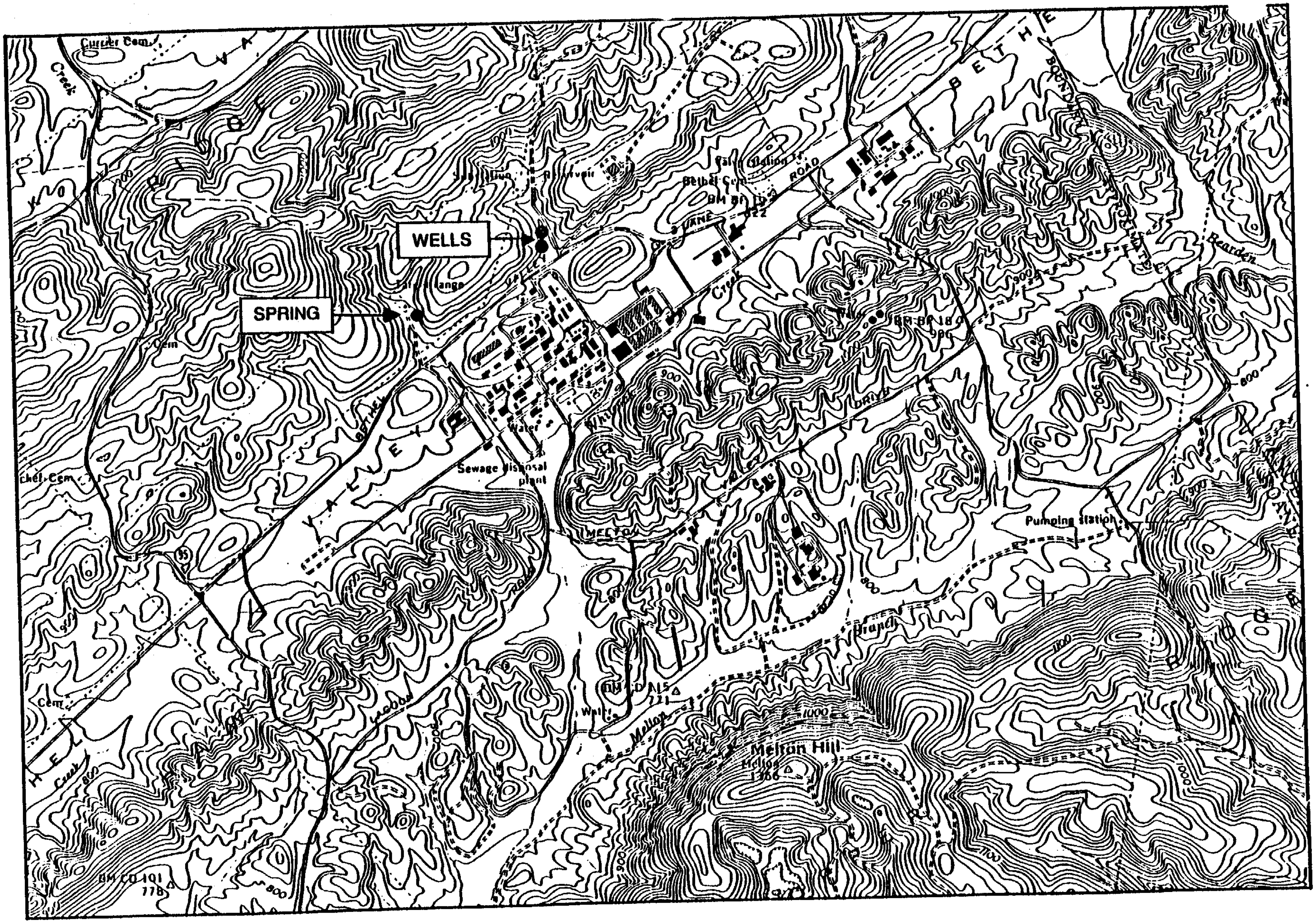


FIGURE 3-11
SECTION OF BETHEL VALLEY QUADRANGLE
SHOWING SPRING SOURCE OF FIRST CREEK

C23/wag1-15

with other types of lines. Figures 3-12 through 3-14 show the locations of the storm sewer outfalls. The outfalls are numbered as members of the 100, 200, or 300 series. The 100 series drains only rainwater; the 200 series drains buildings and parking lots but no process effluent; and the 300 series drains buildings and areas where the presence of untreated process wastes is indicated. Flow volumes for the storm water sewer system are dependent on precipitation.

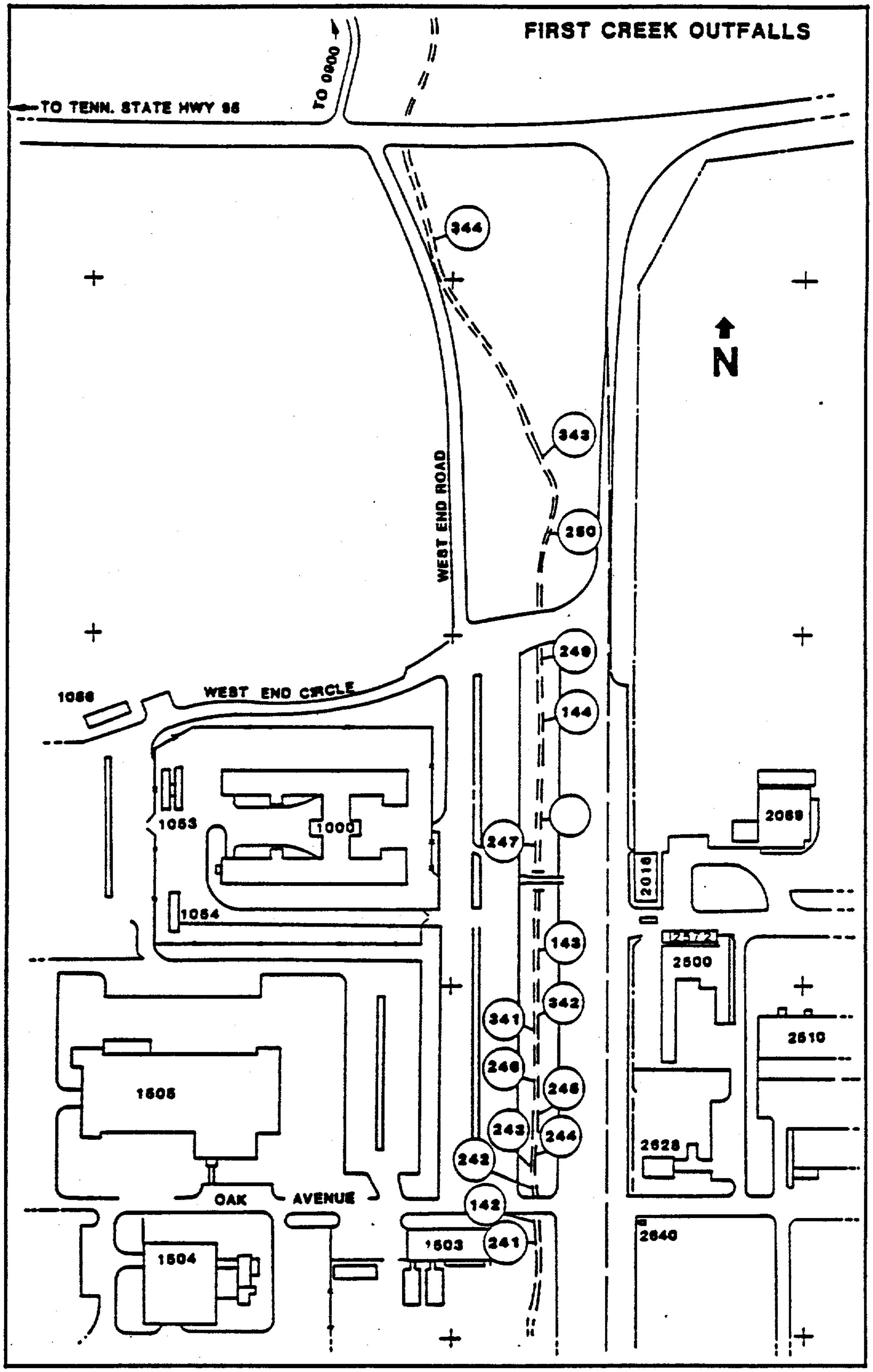
Water samples are collected and analyzed regularly from a number of stations in the WOC and its tributaries in WAG 1. Water is also sampled at the STP and the PWTP as well as in the 3500 area ponds.

Figure 3-15 shows locations of the surface water sampling stations in WAG 1 and vicinity. Table 3-13 is a summary of collection and analysis frequencies of the surface water samples. Table 3-14 shows the radionuclide concentrations in WOC and its tributaries for 1986. It appears that major sources of strontium drain toward First Creek. Considerable dilution occurs in WOC at the 7500 bridge.

A mercury assessment program was implemented in 1988 to identify, locate, and minimize all sources of mercury contamination in ORNL discharges to maintain compliance with the NPDES permitting program (Taylor, 1989) (Figure 3-15a). Surface water samples were collected from selected NPDES outfalls (Categories I, II, and III) and from previously established serial numbered sampling stations, these were submitted for mercury analysis.

The results of this survey indicated several areas with mercury levels significantly above background levels: 1) a storm drain outfall (No. 106) along Southside Drive which enters White Oak Creek south of Building 4508 (Figure 3-15a); 2) the process waste outfall (No. 311) from Building 4500S; 3) the monitoring station (X07) along White Oak Creek serving the PWTP; 4) Outfall No. 367

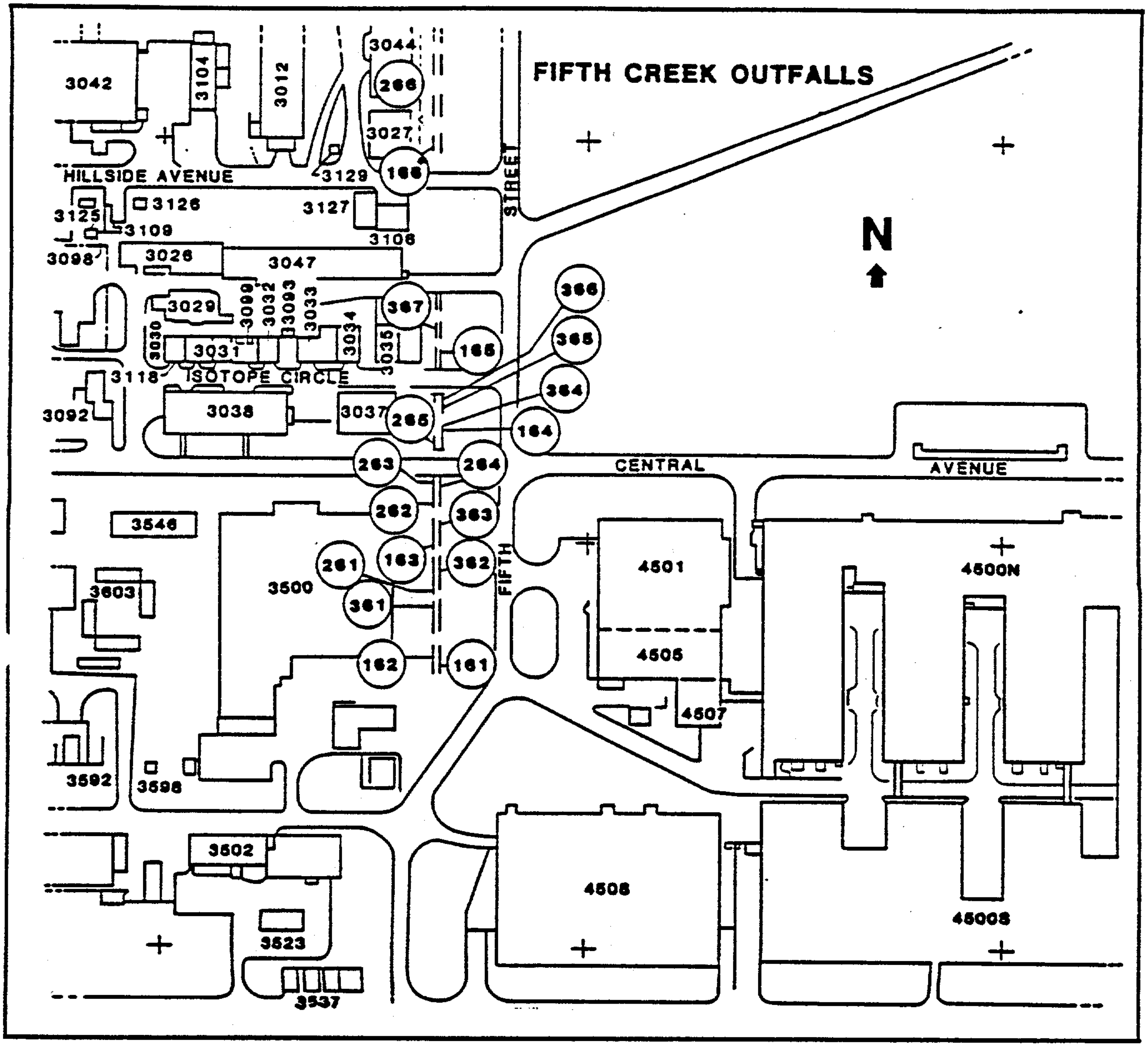
ORNL-DWG 86-819



SOURCE: BOEGLY et al., 1987

FIGURE 3-12
LOCATIONS OF FIRST CREEK OUTFALLS

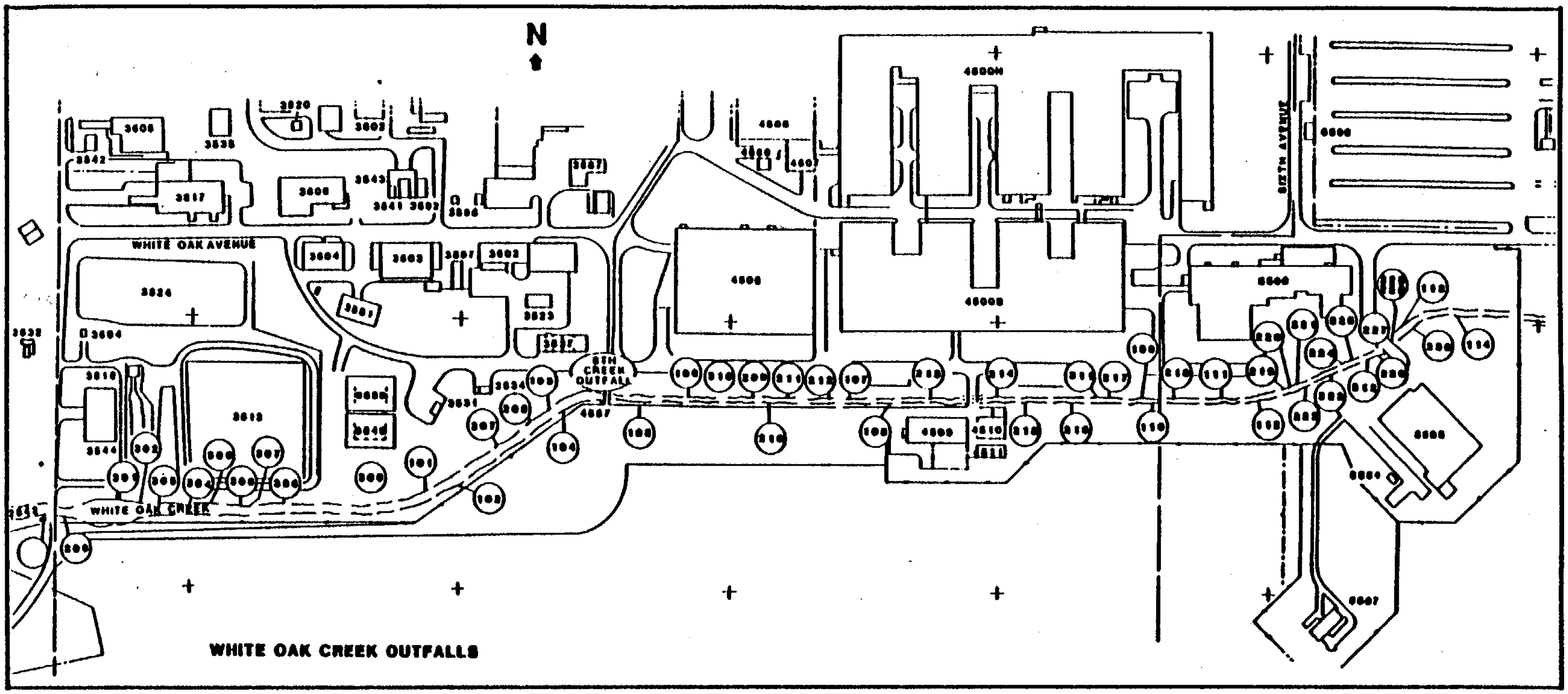
ORNL-DWG 86-818



SOURCE: BOEGLY et al., 1987

FIGURE 3-13
LOCATIONS OF FIFTH CREEK OUTFALLS

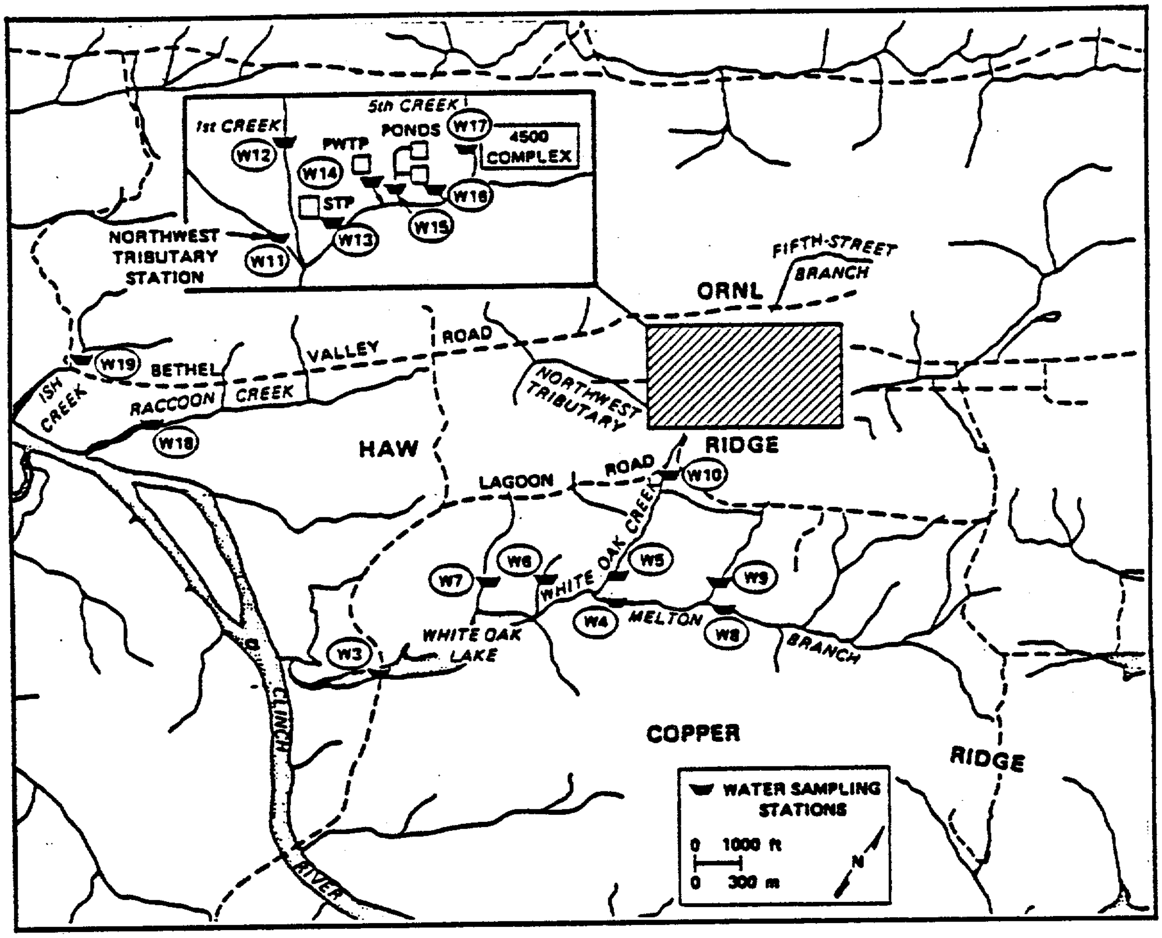
ORNL-DWG 86-620



SOURCE: BOEGLY et al., 1987

FIGURE 3-14
LOCATIONS OF WHITE OAK CREEK OUTFALLS

ORNL-DWG 86-10083R



7500 BRIDGE	W10
NORTHWEST TRIBUTARY	W11
FIRST CREEK	W12
STP	W13
PWTP	W14
3500 (190 PONDS) PONDS	W15
FLUME STATION 2	W16
FIFTH CREEK	W17

FIGURE 3-15
SAMPLING STATIONS IN WAG 1 AND VICINITY

TABLE 3-13

SUMMARY OF COLLECTION AND ANALYSIS FREQUENCIES OF SURFACE WATER SAMPLES

Station	Parameter	Collection Frequency	Type	Analysis Frequency
190 Ponds	Gamma Scan, gross alpha, gross beta	Weekly	Flow Proportional	Monthly
1500 Area, 3518	Gross alpha, gross beta	Weekly	Flow Proportional	Monthly
2000 Area, STP	Gamma scan, gross beta, total Sr[a]	Weekly	Flow Proportional	Monthly
3544	Gross alpha, gross beta, gamma scan, total Sr[a]	Weekly	Flow Proportional	Monthly
7500 Bridge	Gamma scan, total Sr[a]	Daily	Time Proportional	Daily
7500 Bridge Monthly	Gamma scan, total Sr[a], ^{3}H		Weekly Proportional	Flow
First Creek, Fifth Creek, NWT	Gamma scan, total Sr[a]	Weekly	Grab	Monthly

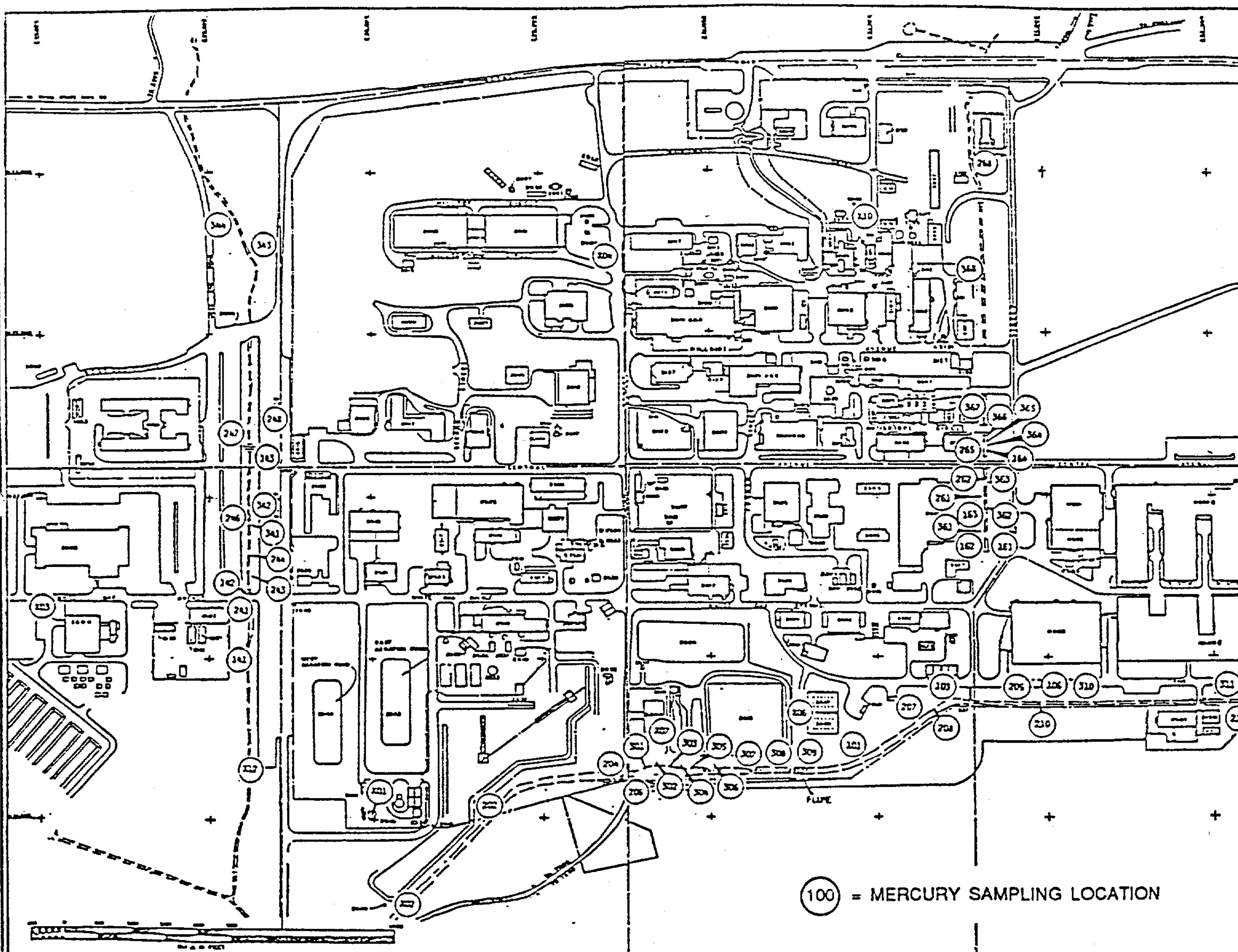
[a] Total radioactive Sr ($^{89}Sr + ^{90}Sr$)

TABLE 3-14

1986 RADIONUCLIDE CONCENTRATIONS IN WATERS OF WOC AND TRIBUTARIES IN WAG 1

Radionuclides	Number of Samples	Concentrations (pCi/L) Max	Min	Av	95% CC
		First Creek			
^{60}Co	12	13	<2.7	<6.3	1.9
^{137}Cs	12	<27	<2.4	<7.4	4.0
Total Sr	12	1000	250	590	140
		Fifth Creek			
^{60}Co	12	<11	<1.6	<5.2	1.8
^{137}Cs	12	<8.1	<1.3	<4.8	1.6
Total Sr	12	54	25	39	5.1
		7500 Bridge			
^{60}Co	12	140	4.9	24	24
^{137}Cs	12	230	59	160	30
^{3}H	12	8200	<3200	<5900	1100
Total Sr	12	150	68	104	17

1 Bq = 27.03 pCi



SOURCE: Taylor (1989).

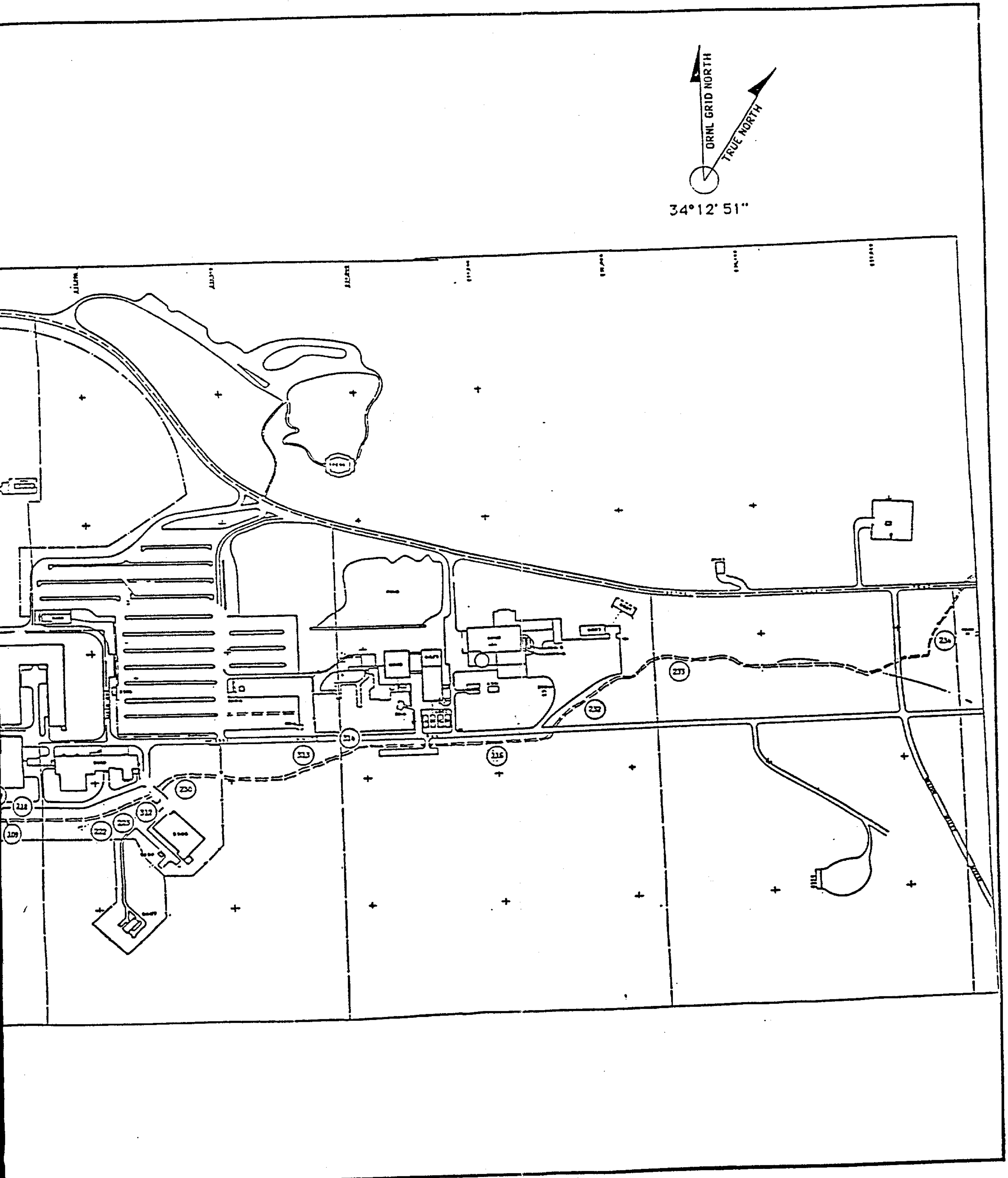


FIGURE 3-15A
MERCURY SURFACE WATER SAMPLING
STATIONS IN THE ORNL BETHEL VALLEY
COMPLEX

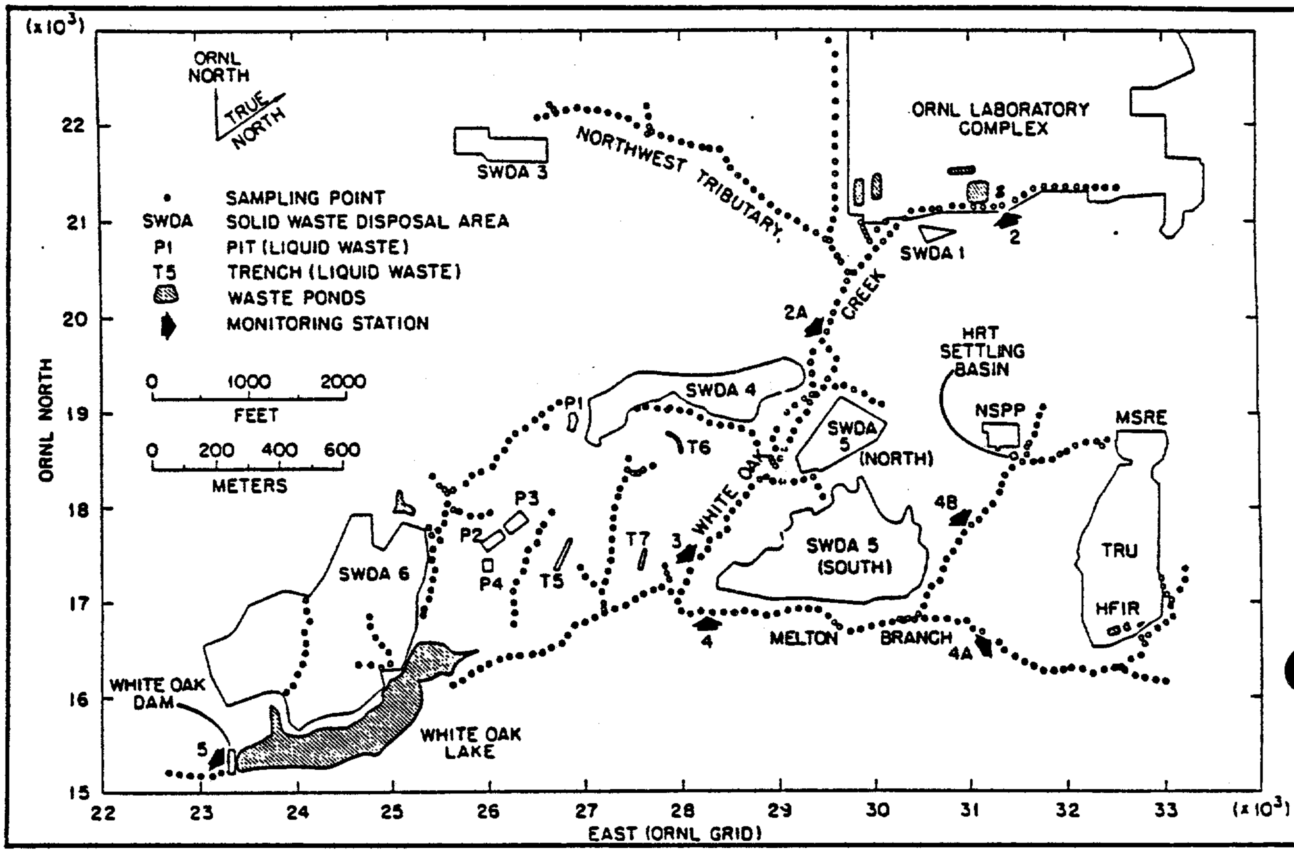
along Fifth Creek near Building 3036; 5) Outfall No. 261, which discharges to White Oak Creek and receives runoff from roof drains, spill areas, and cooling water discharges from the Building 3500 area; and 6) Outfall No. 309 which receives discharges from Building 4500S through Holding Basins 3539 and 3540 and discharges to White Oak Creek.

Stream gravel surveys in the WOC watershed were conducted by Cerling and Spalding (1981) to define the areal distribution of cobalt-60, cesium-137 and strontium-90. Later studies (Cerling and Huff, 1986; Morrison and Cerling, 1987) corroborated the general findings of the earlier study. Figure 3-16 gives the locations of sediment sampling points including those within the WAG 1 area used by Cerling and Spalding.

Table 3-15 gives the ranges of concentrations of various radionuclides found in WOC, First Creek, and Northwest Tributary sediments (Fifth Creek sediments were not sampled).

The principal source of cesium-137 is the PWTP. The principal sources of strontium-90 are direct ORNL plant effluents, and cooling water effluent from the High Flux Isotope Reactor is the dominant

ORNL-DWG 79-13979



SOURCE: CERLING AND SPALDING (1981)

FIGURE 3-16
SEDIMENT SAMPLING POINTS USED IN CERLING AND SPALDING STUDY

TABLE 3-15

RANGES OF RADIONUCLIDE CONCENTRATIONS
IN STREAM SEDIMENT WITHIN WAG 1

Stream	Range of Concentration dpm/g		
	^{90}Sr	^{60}Co	^{137}Cs
White Oak Creek	5-50	1-1000	1-10,000
First Creek	0-10	0-1	0-1000
Northwest Tributary	0-1	0-1	0-10

[1] Bq = 60 dpm

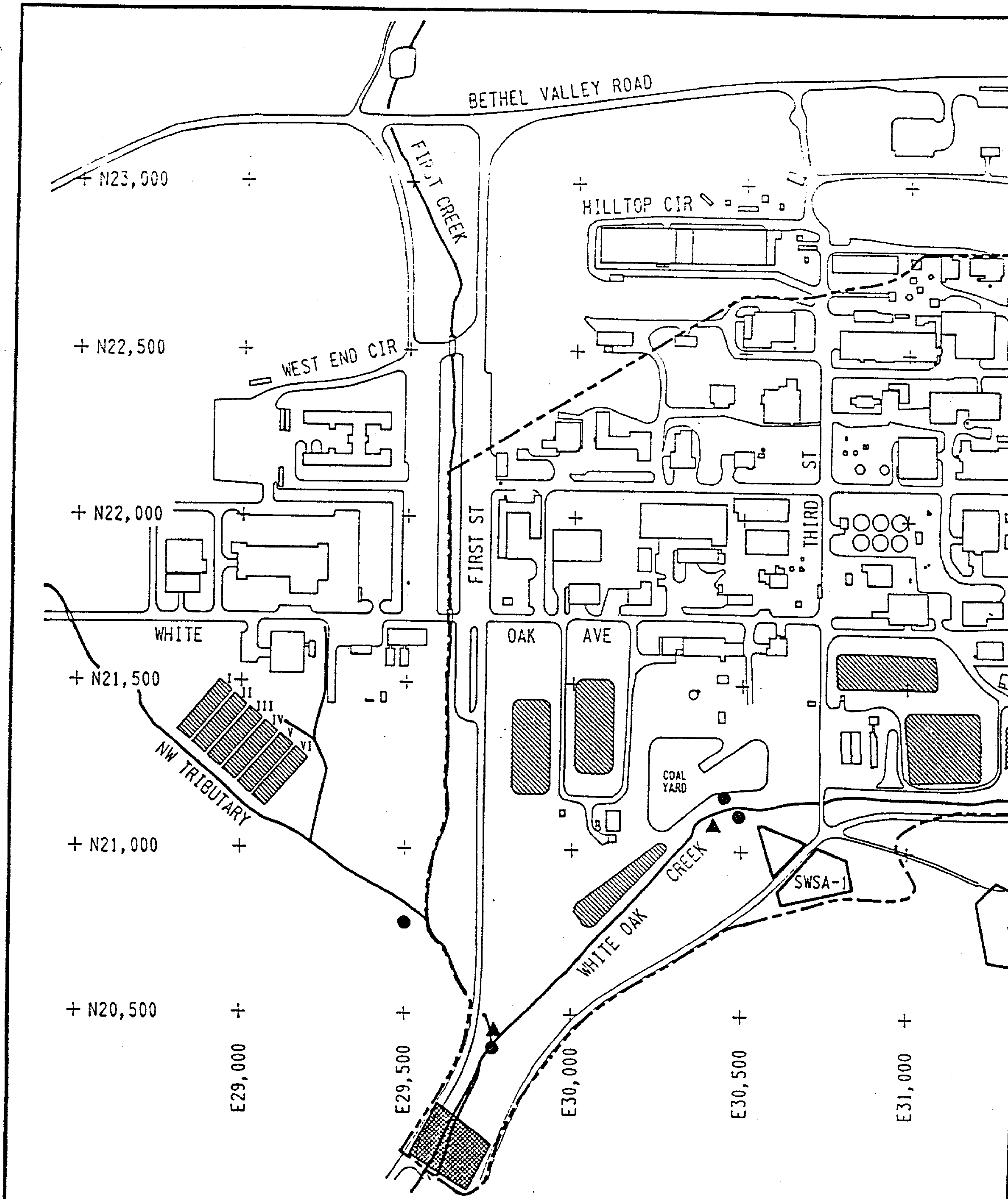
source of cobalt-60. Sediment contamination to a depth of 30 cm has been observed. In addition to radiological contamination, stream sediments are contaminated with a variety of metals including chromium, copper, molybdenum, and zinc (Boegly et al., 1987). Contamination with metals probably results from cooling towers, unknown sources along First Creek and the Northwest Tributary, or from sources that have not been identified.

Sediments

Sediment samples have been collected from various WAG 1 locations for mercury and radiochemical analyses. Figure 3-16a gives the locations of the WAG 1 sediment sampling locations. This figure also indicates samples collected from the 7500 Bridge Area on White Oak Creek. Although this area is not within the confines of WAG 1, samples from this area may represent contaminants transported from WAG 1 and are, therefore, included in this section.

The results of the mercury analyses are summarized in Table 3-15a. Mercury levels significantly above background levels were discovered in Fifth Creek and in White Oak Creek below the confluence with Fifth Creek (Figure 3-16b). Mercury levels in Fifth Creek probably represent past spills from the lithium isotope separation/uranium-thorium metal production processes associated with Buildings 4501 and 4505 (Taylor, 1989). Mercury levels in White Oak Creek may indicate contamination resulting from the Central Research Complex, Building 4500 (Taylor, 1989). Mercury also was used widely in fuel reprocessing, which was occurring before the construction of Building 4500 (Trabalka, 1989). To date, no attempt has been made to define the lateral or vertical extent of the mercury contamination.

Samples were also collected in Fifth Creek and in White Oak Creek near the 7500 Bridge for radionuclide analyses (Figure 3-16a,



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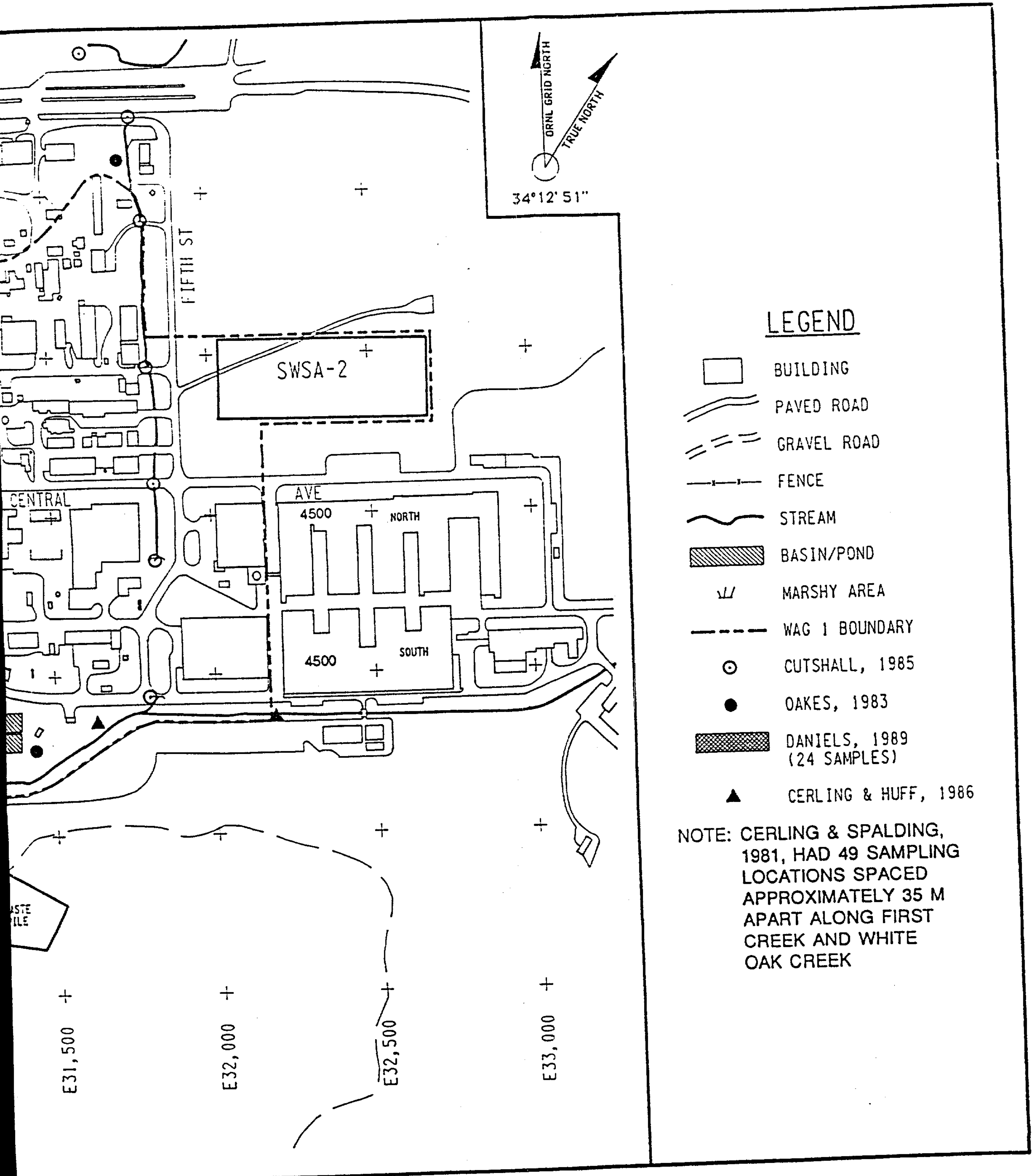


FIGURE 3-16A
APPROXIMATE LOCATIONS OF SEDIMENT SAMPLES COLLECTED FROM WAG 1

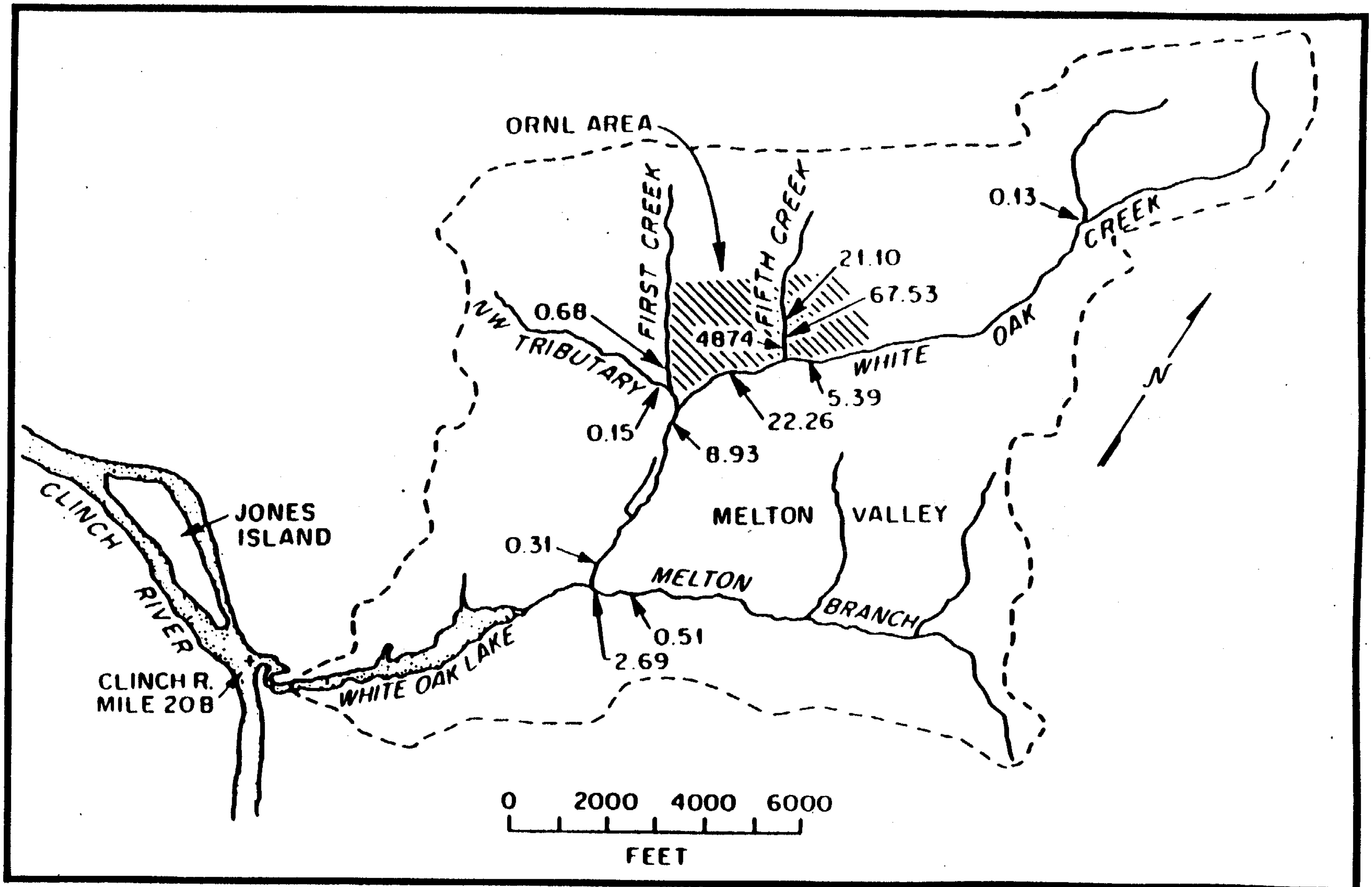
TABLE 3-15a

RANGES OF MERCURY CONCENTRATIONS IN STREAM SEDIMENTS WITHIN WAG 1

Location	Concentration (µg/g)	Reference
White Oak Creek		
Above WAG 1 Boundary	0.1 - 0.3	Oakes[a] & Taylor[b]
Upstream of Fifth Creek	5.3	Taylor
Near Outfall 309	22.2	Taylor
Upstream of Equalization Basin	1.6 - 9.5	Oakes
Downstream of Equalization Basin	0.4 - 19	Oakes
Downstream of First Creek	0.41 - 8.93	Oakes & Taylor
Fifth Creek		
Outfall Box 362	21.1	Taylor
Below Outfall 362	67.5	Taylor
Near Outfall 261	4874	Taylor
First Creek		
Upstream of Northwest Tributary	0.67	Taylor
Northwest Tributary		
Below SWSA 3	0.04	Oakes
Upstream of First Creek	0.17	Taylor

(a) These results include data from samples collected in 1979 and 1983. The 1979 samples consisted of surface sediments, less than 3 in. deep. The 1983 samples consisted of 10-in. deep core samples, divided into thirds for analyses.

(b) These results consist of surface sediment grab samples collected as part of the NPDES mercury assessment.



SOURCE: Taylor (1989).

FIGURE 3-16B
LOCATIONS IN ORNL STREAMS WITH EXCESS MERCURY CONCENTRATIONS IN SEDIMENTS

Table 3-15b). The results of these analyses indicated the presence of various radioisotopes in the sediments at the 7500 Bridge, including Cs-137, Co-60, Eu-152, Eu-154, Ba-133, and Cs-134 (Daniels, 1989).

In Fifth Creek, various fission products were identified including Cd-115, Cs-134, Eu-152, Eu-154, Gd-153, and Co-60 (Cutshall, 1985) (Figure 3-16a). The types of radionuclides discovered in Fifth Creek implied that the contamination resulted from cooling tower and reactor coolant discharges.

Oakes (1983) reported mercury levels for sediment samples collected from White Oak Creek in 1979 and 1983. Those located within WAG 1 are shown in Table 3-15c. All values except one were higher than the EP Toxicity limit of 0.2 ppm established by EPA. The highest value recorded for 1979 was 3.8 ppm at site T-10, which is located just downstream of the equalization basin and the process waste settling basin. Samples collected in 1983 from a similar location had mercury levels at 18 and 19 ppm.

3.3.1.4 <u>Groundwater</u>. Groundwater movement beneath WAG 1 is not well defined, although a review of published documents and conversations with ORNL investigators suggest that there are several flow regimes of concern in this investigation. Reports by Stockdale (1951), Webster (1976), and Steuber et al. (1981), and conversations with R. Ketelle (ORNL) describe plant-scale studies at ORNL or within Bethel Valley. Groundwater is observed to occur both in the unconsolidated overburden and within the bedrock; however, communication between these zones has not been fully evaluated. A summary of existing groundwater conditions, followed by study-specific findings, is reported below.

The uppermost portion of the aquifer occurs under unconfined conditions. Recharge to the system is generally through infiltration with localized recharge through surface impoundments (3500 area ponds). The water table appears as a subdued replica

TABLE 3-15b

RANGE OF RADIONUCLIDE CONCENTRATIONS DETECTED IN SEDIMENTS AT THE 7500 BRIDGE

Radioisotope	Concentration Range (Bq/Kg)
Cs-137	2,300 - 290,000
Co-60	11 - 17,000
Eu-154	190 - 1,200
Eu-152	78 - 2,900
Cs-134	72 - 270
U-234	52 - 170
Ba-133	510
Am-241	46 - 160
Cm-244	80 - 680
Th-232	15 - 56
Th-230	11 - 36
Th-228	18 - 55
Sr-90	37 - 1,100
Pu-239	110 - 160
Pu-238	4.9 - 39
U-238	28 - 75

Source: Daniels (1989).

TABLE 3-15c

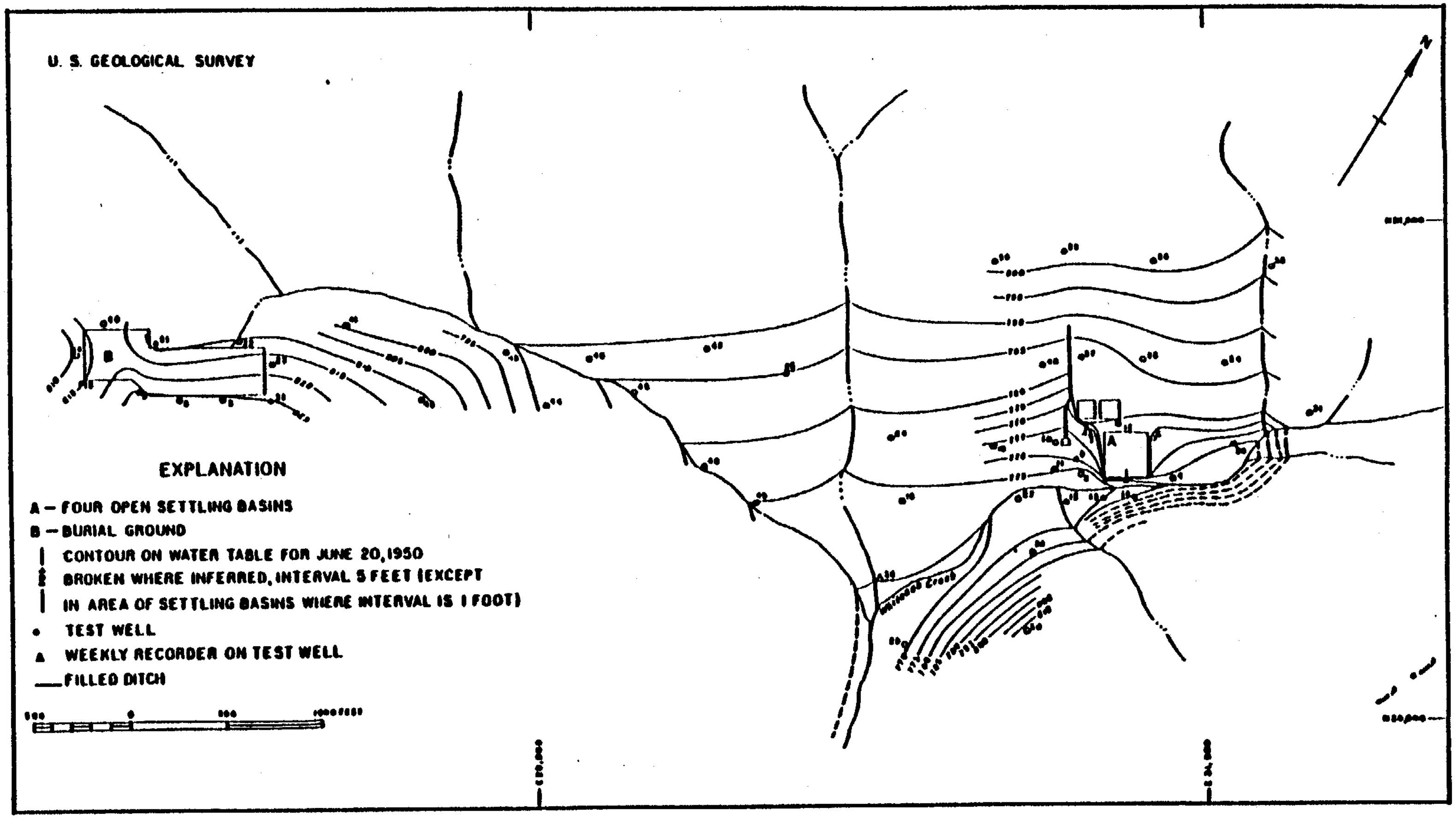
CONCENTRATION OF MERCURY IN SEDIMENT SAMPLES COLLECTED FROM WAG 1 IN 1979 AND 1983

Sampling Location	Concentration (ppm)
1979	
P-6	0.08
T-8	0.41
T-10	3.8
1983	
6-LT[a]	2.9
6-LM	2.0
6-LB	6.4
6-RT	9.5
6-RM	1.6
6-RB	2.8
7-RT	5.1
7-RM	18
7-RB	19
7-LT	8.1
7-LB	0.4
8-RT	2.5
8-RM	4.5
8-RB	1.4

[a] R, M, and L indicate right, middle, and left of stream looking downstream. T, M, and B indicate top, middle, and bottom of a 10-in. core.

of ground surface topography. Under isotropic and homogeneous conditions, flow perpendicular to the groundwater contours shown in Figure 3-17 would be predicted. However, local flow patterns at ORNL are significantly affected by activities in the anthropogenic zone including active sump pumps, directional permeabilities, and local recharge from impoundments and leaking pipes. Additionally, vertical gradients have not been well defined and are likely influenced by directional permeabilities in bedrock. Thus, current piezometric surface data are of limited use in establishing local flow patterns.

Flow of groundwater in bedrock may be highly influenced by directional permeabilities in bedrock, including at least flow



SOURCE: STOCKDALE (1951)

FIGURE 3-17
WATER TABLE MAP OF THE OAK RIDGE NATIONAL LABORATORY AREA

through jointed and fractured bedrock, interconnected solution cavities and channels, and along bedding planes. Additionally, vertical gradients--both upward and downward within the aquifer--may be present. Components of flow that have been identified in certain portions of the site include horizontal (parallel to strike), horizontal (between units), horizontal (between groups), and vertical. A strong flow component parallel to strike both on-site and in Bethel Valley has also been reported.

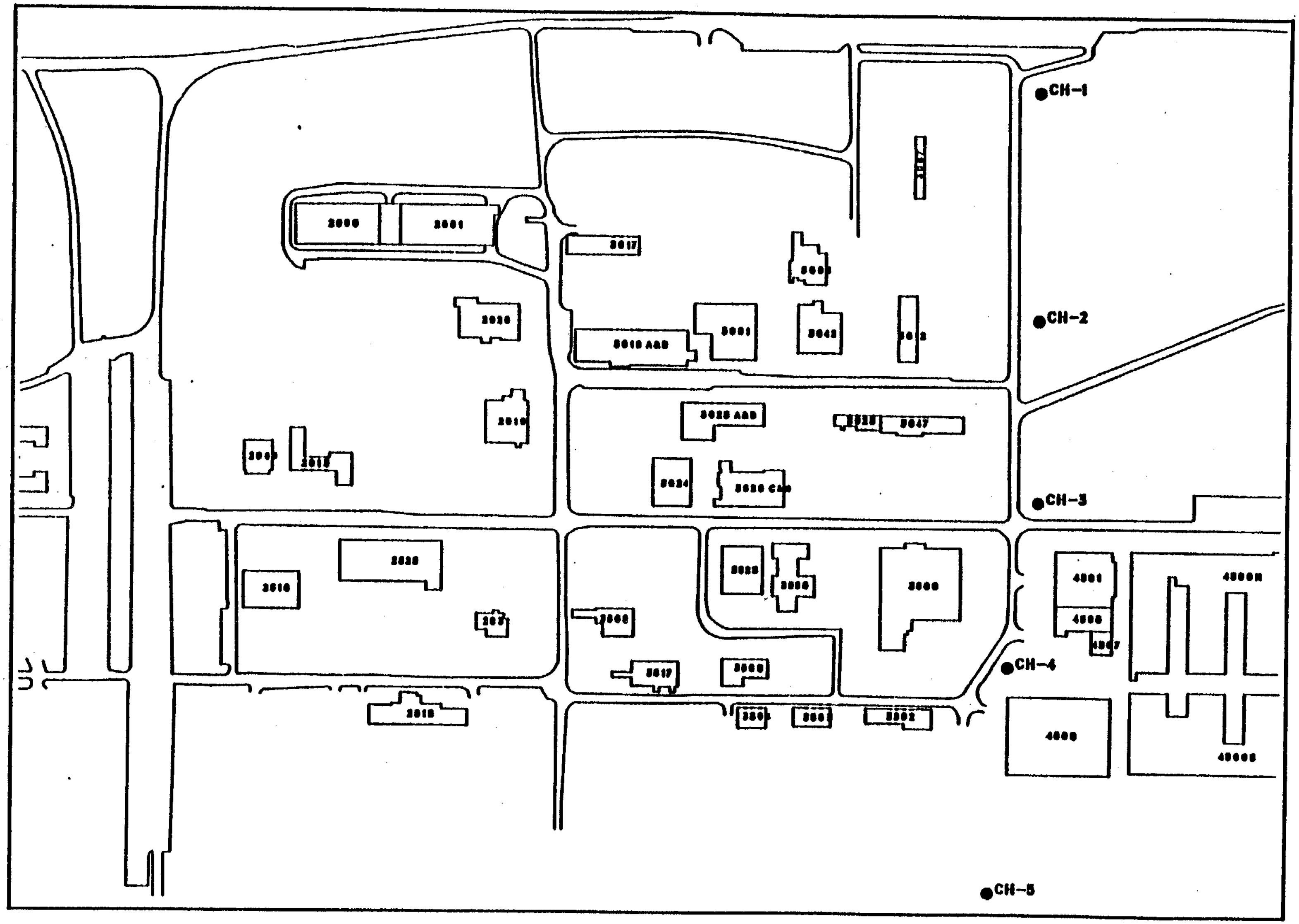
Stockdale (1951) conducted the earliest studies to characterize local groundwater flow. Stockdale's studies of the site, including coring and pressure testing bedrock, indicated that communication exists between solution cavities (1-in. to 12-in. diameter) in Unit G and the 3513 pond. He judged that the Copper Creek fault presented an impervious barrier to horizontal groundwater flow between the Chickamauga Group and the Rome Formation, and that Unit F of the Chickamauga Group functioned as a stratigraphic trap for groundwater, preventing its horizontal flow. Recharge to the area primarily occurs through the infiltration of meteoric waters and local recharge conditions (e.g., surface impoundments). Stockdale developed a water table map, which depicts the groundwater surface as a subdued replica of the overlying surface topography with minor distortions attributed to recharge from the 3500 area ponds (Figure 3-17).

Webster (1976) suggested that groundwater movement should not be plotted on the basis of Stockdale's water table maps, mainly because of the anisotropic nature of the bedrock. From core logs and Stockdale's pressure tests, he concluded that solution cavity size and frequency of occurrence diminished with depth, and that circulation of groundwater in the Chickamauga Group may be restricted to the upper several hundred feet. More recent work by Stueber and Webster (1981) provided information on flow component parallel to strike within the Chickamauga Group in Bethel Valley. This is supported by observations made on-site by Ketelle et al. (1985) that fluids lost during drilling were returned at the surface parallel to strike through discharge to Fifth Creek. This also indicates that flow beneath WOC and its tributaries and discharge to those same streams are possible scenarios for groundwater movement.

An additional observation made by Ketelle et al. (1986) is the presence of artesian conditions at depth in the Chickamauga, evidenced by flowing wells (Figure 3-18) and elevated pore pressures at depth, thus indicating the presence of both upward and downward vertical gradients at the site. Ketelle et al. (1986) also observed a reduction in flow in two coreholes during pump testing of two wells installed north of Bethel Valley Road (Figure 3-11). Further investigation of the construction of these two supply wells indicates that water is being pumped from both the Chickamauga and Knox groups in each of the wells. The source of the influence is thus not well defined. The possibility exists that there is communication across the units of the Chickamauga as well as the potential for communication between the Knox and Chickamauga groups.

Huff (1985) conducted a dry weather dye tracer study to investigate a LLW transfer line leak between Buildings 3019 and 3074 in WAG 1. The study showed movement of groundwater parallel to strike toward a sump located in the Oak Ridge Research Reactor building and movement around Building 3019. The study concluded that flow towards the Oak Ridge Research Reactor sump was controlled by directional permeabilities in bedrock (solution cavity, joints, fractures) and an induced hydraulic gradient towards the Oak Ridge Research Reactor sump. Flow around Building 3019 was reported as a function of directional permeabilities in the anthropogenic zone--along pipelines within permeable backfills.

A piezometer well network has been developed within WAG 1 to observe groundwater levels. A description of the approach used in developing these wells and subsequent interpretation of data is provided in Ketelle et al. (1986). Figure 3-19 shows the water



SOURCE: KETELLE et al., 1986

FIGURE 3-18
LOCATIONS OF COREHOLES DRILLED AT OAK RIDGE NATIONAL LABORATORY

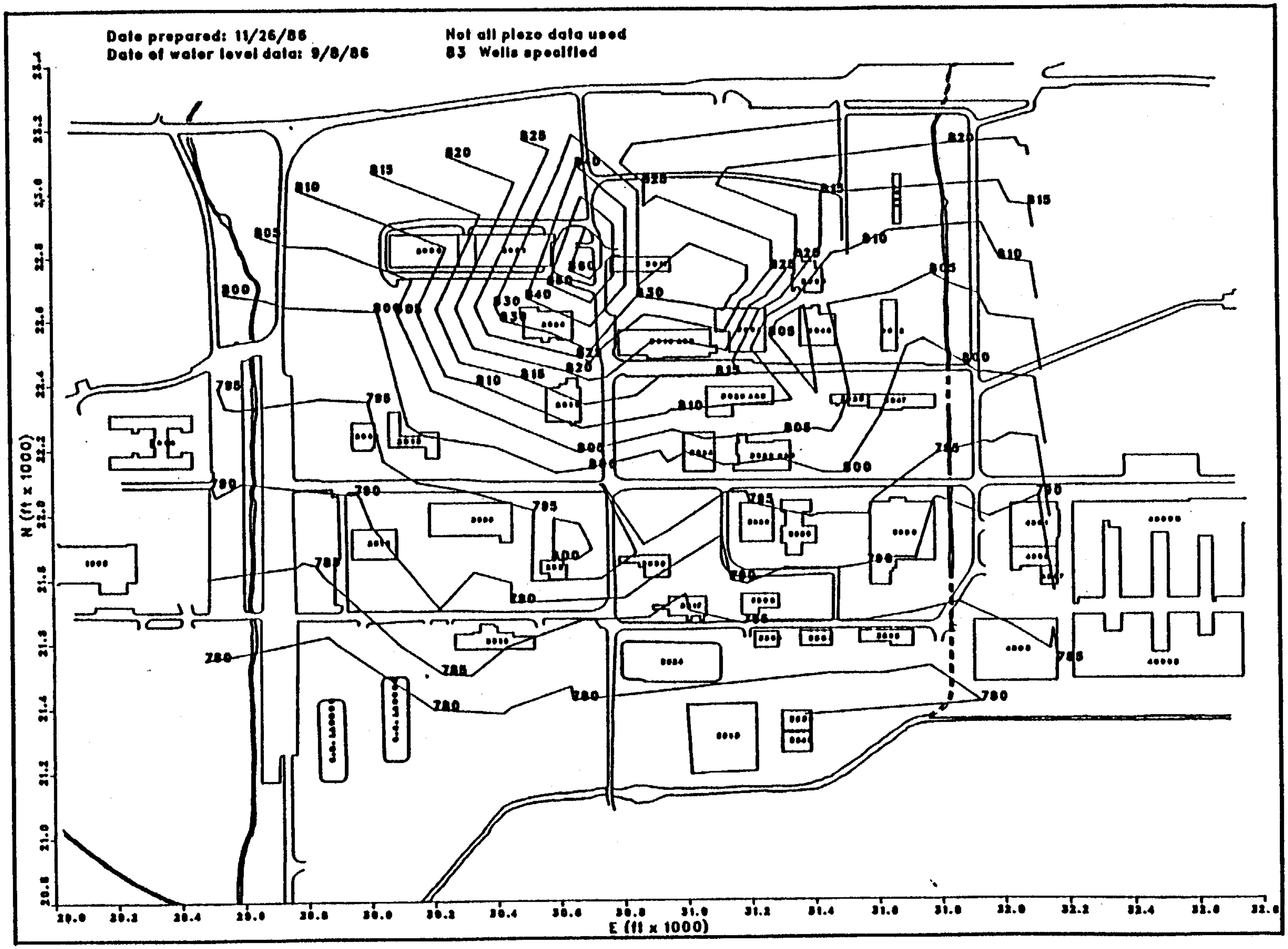


FIGURE 3-19
WELLS AT ORNL SHOWING WATER LEVEL ELEVATIONS IN FEET

table contour based on the piezometer observations. As in the Stockdale contour map (Figure 3-17), the water table follows the contours of the surface topography.

Groundwater monitoring at WAG 1 has been limited to (1) a contaminant scoping event that occurred during the period April to July 1986, and (2) quarterly sampling of compliance wells around the 3500 series ponds that was conducted for a period of one year (1985-86).

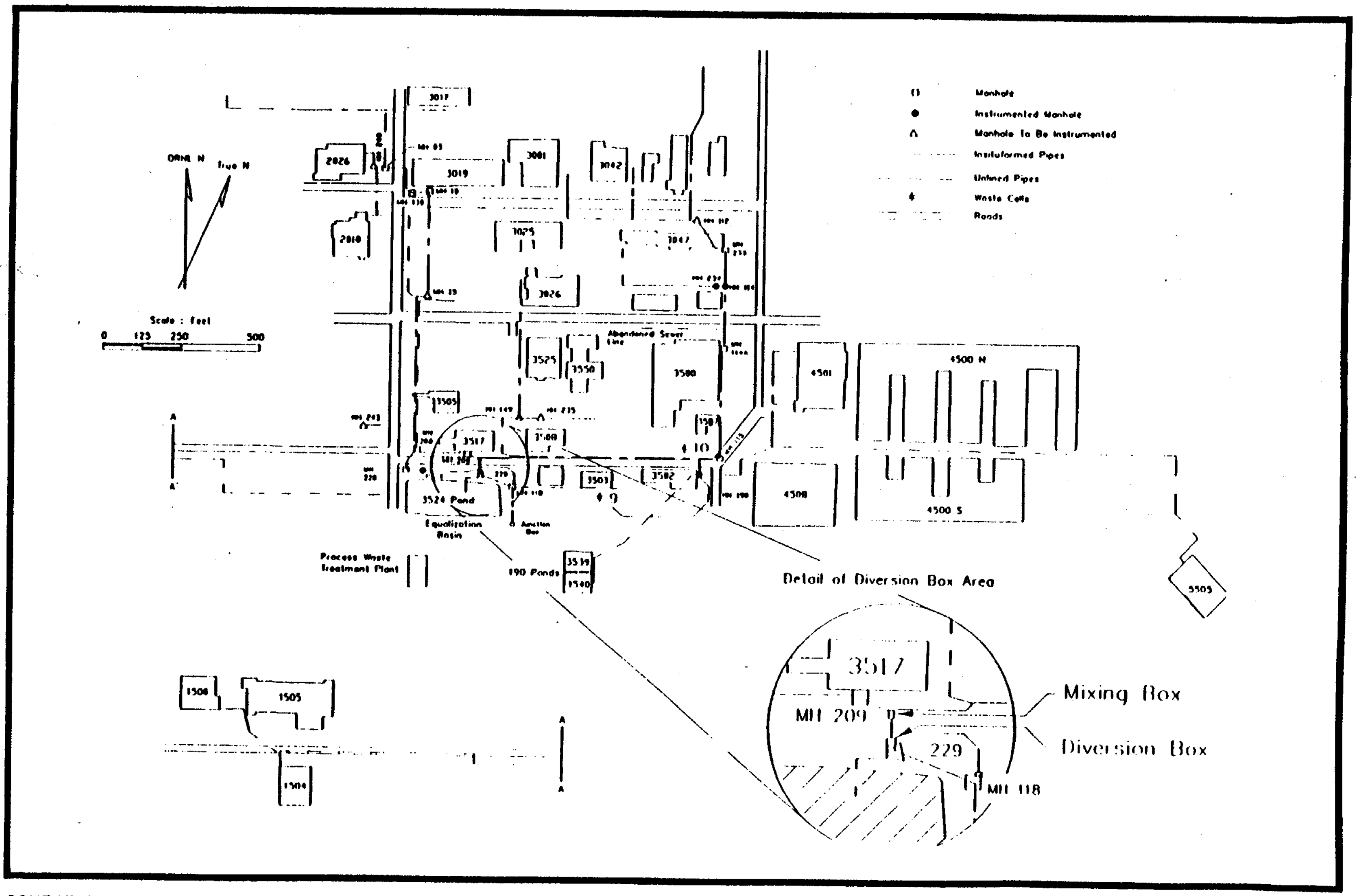
The purpose of the scoping event was to investigate what types of chemical and radioactive constituents were present in groundwater at the site. Groundwater samples obtained during the scoping event were collected from wells in the polyvinylchloride (PVC) piezometer well network. Each well was purged prior to sampling using a PVC bailer by evacuating three well volumes; the well was then sampled using the same bailer. Samples were not collected on the same date; rather the period extended from April to July 1986. The full suite of parameters that were included as part of the scoping event are included in Table 3-16. The summary of the parameters detected during the scoping event is provided in Table 3-17.

The monitoring of the stainless steel compliance well network installed around the 3500 series ponds occurred for a period of one year. Wells were purged prior to sampling using dedicated bladder pumps by evacuating three well volumes; wells were sampled following purging using the same pump. Samples were collected quarterly during 1985-86; records obtained during this sampling event were documented in reports submitted to the Tennessee Department of Health and Environment (TDHE) and met at least the minimum requirements of the state. Tables 3-18 and 3-19 summarize the findings of these quarterly sampling events. The 31 parameters shown in both tables are the full suite of parameters for which these samples were analyzed.

New groundwater data collected since the original RI Plan for WAG 1 was submitted have been made available to the RI Team. Principal among these were studies by: 1) Yager et al. (1989), which investigated the infiltration of extraneous water into the process waste system (PWS); 2) Arnseth (1987), which evaluated data collected by Ketelle from piezometers; 3) Chen et al. (1988), which assessed the influence of differential hydraulic conductivity of pipeline trenches on groundwater flow; 4) Ashwood (1988), which presented the general status report on flow in pipeline trenches; 5) Melroy (1986), which investigated groundwater contamination migration pathways from the leak site north of Building 3019; and 6) Hall (1989), which monitored infiltration into drywells at the Tank Farms. This information has been utilized in the revised field sampling plan. Brief summaries of these documents follow.

Typical construction for the process waste system at WAG 1 involves pipelines installed in excavated trenches. These trenches are then backfilled with soil, gravel, or other materials, the hydraulic conductivity of which may be several orders of magnitude higher than native materials. These pipeline trenches may, therefore, serve as preferred pathways for water flow and contaminant transport.

Yager et al. (1989), in their review of infiltration of extraneous water into the process waste system (PWS), analyzed the interconnectedness and functions of that system. The following is a summary of current PWS cooperations. Low-level radioactive process waste is collected and transported by the PWS and treated at the Process Waste Treatment Plant (PWTP). In addition to the normally generated process waste, the PWS also collects condensate from the LLW evaporator and other waters that may be contaminated. PWS discharge data are presently collected at three locations: Manhole 114, Pumping Station (PS) 1, and at the inlet to the Equalization Basin (Pond 3524d) (Figure 3-19a). These data can be used to generally characterize the flow within



SOURCE: Yager et al. (1989).

FIGURE 3-19A
SCHEMATIC OF PROCESS WASTE SYSTEM IN WAG 1

the PWS but only on a macroscopic scale. Manhole 114, which is located at the eastern end of Isotope Circle, receives process wastes generated in the northeast section of the 3000 area. PS1 receives contaminated groundwater seepage from sumps beneath the north and south tank farms. From PS1 the process waste is pumped to a diversion box further to the east. All water entering the diversion box then flows south by gravity to the Equalization Basin, from which it is pumped to the PWTP for treatment prior to being discharged to White Oak Lake. Yager et al. (1989) attempted to correlate the flow within the PWS with rainfall and found no direct relationship. They concluded that the main source of water for PS1 was groundwater seepage from the north and south tank farms and from a gravel-backfilled trench in which the process waste line between the tank farms and PS1 is located. Water collected from the tank farms flows into an 8-in. vitrified clay pipe, which has not been insituform lined. Therefore, it is likely that relatively large amounts of groundwater enter the PWS by direct infiltration into this pipe.

Manhole 114 receives process waste from Manhole 233 via a 10-in. pipe; Manhole 233, in turn, is connected to Manhole 112 by an 8-in. pipe that runs beneath Building 2047. Because both these connecting pipes have been insituform lined, it is unlikely that water is entering the PWS by infiltration through the pipes. Yager et al. (1989) concluded that an unknown source is contributing contaminated flow to the PWS through an opening in Manhole 233.

Waste Cells 9 and 10 are underground concrete waste storage vaults. Waste Cell 9 is south of building 3503, and Waste Cell 10 is near the intersection of Fifth Street and White Oak Avenue in the 3000 area. These waste cells are equipped with sumps to preclude groundwater from contacting the tanks. Yager et al. (1989) concluded that extraneous water enters the PWS at these locations by groundwater seepage into the sumps. They further state that at some locations, the flow rates may be too high for the sole source to be only groundwater infiltration, a point that Moore (1989) suggests may be the result of influx from the storm sewer system. The primary implication of the results of this investigation is that there are many potential avenues through which extraneous water can enter the PWS. The interconnectedness of the PWS, waste storage areas, pipelines, trenches, and groundwater provides opportunities for contaminant mobilization and migration.

Arnseth (1987), in an evaluation of the usefulness of statistical pattern recognition techniques for classifying contaminated versus uncontaminated water in WAG 1, subjected the preliminary data collected by Ketelle et al. (1986) from piezometers in the study area to factor analysis. Although factor analysis was shown to have potential for accomplishing the desired results, this exercise questioned the validity of the data. Several factors contributed to this assessment. Determining the charge balance, which should be near zero for cations and anions, revealed that in the samples there were more than twice as many cation equivalents as anion equivalents. Following discussions with persons involved in both the sampling and analysis, Arnseth learned that the original samples were turbid, which likely affected the ICP analysis and the alkalinity titration. He recommended that future scoping studies use standardized procedures that required filtering of samples to be subjected to ICP and alkalinity analyses.

Chen et al. (1988) used a computer simulation model to evaluate water flow through saturated and unsaturated media. They found that the water level in both the trenches and the surrounding materials tend to follow the bedrock surface topography and that shallow groundwater flow in the WAG 1 area is toward White Oak Creek. The conductivity contrast (i.e., the ratio of hydraulic conductivity in the backfill to that in the native soil) influences the flow into the creek and the percentage of flow through the trenches. In fact, at a conductivity contrast of only 10, nearly half the flow occurs through the trenches; as the conductivity contrast approaches 200, nearly all the flow is in the pipeline trenches. The most important conclusion from this study was that shallow groundwater flow in the vicinity of the Equalization Basin (3524) and the PWTP (3544) is dominated by flow in pipeline trenches.

Similarly, Ashwood (1988) in his status report on flow in pipeline trenches in WAG 1 concluded that pipeline trenches exert considerable control on the near-surface flow of groundwater. Thus, much of the contamination in the Main Plant Area should be at a depth interval where pipeline trenches dominate the groundwater flow patterns.

Melroy (1986) determined using a fluorescein dye tracer that there were two major groundwater migration pathways at the leak site north of Building 3019. The first flow component moves almost due east to the Building 3042 sump along geologic strike. The second flow component moves to the southeast. In addition, the fluorescein dye has been detected in several locations in the sanitary sewer system and the process water lines indicating that some infiltration must be occurring, even during relatively dry conditions.

Data from inleakage to the dry wells at the North and South Tank Farms in WAG 1 indicate that water is infiltrating into the wells. However, based upon analysis of water samples, this appears to be groundwater entering the dry wells rather than liquids from leaking tanks (Hall, 1989).

ORNL has sampled the groundwater monitoring wells at WAG 1 twice. Results from the first round of sampling are available from ORNL's Environmental Monitoring and Compliance Group (MMES, 1989); the second set of analytical data are not yet available. Locations of these wells are shown in Appendix A, Figure A3-1. Analyses were run for the groundwater quality constituents listed in 40 CFR 265 and selected radionuclides. Results showed that Well 812, which is located in the 2000 area, had the highest levels of contamination. Gross alpha was 8.6 Bq/L, gross beta was 660 Bq/L, total radioactive strontium was 280 Bq/L, and tritium was 280 Bq/L. Wells 820, 822, and 823, all of which are near the 3000 area and SWSA 2, had tritium levels of 200, 290, and 140, respectively.

TABLE 3-16

CHEMICAL PARAMETERS INCLUDED IN THE CONTAMINANT SCOPING SURVEY

<u>Cations</u>

Ag	Cu	Pb
Al	Fe	Sb
As	Ga	Se
B	Li	Sn
Ba	Mg	Sr
Be	Mn	Ti
Ca	Mo	V
Cd	Na	Zn
Co	Ni	Zr
Cr	P	

<u>Anions measured by ion chromatography</u>

Br	NO_3
Cl	PO_4
F	SO_4

<u>Anions measured by titration</u>

CO_3	HCO_3

<u>Radiological Parameters</u>

Tritium	Gross beta
Gross alpha	Gamma scan

<u>Organic parameters</u>

Total Organic Carbon (TOC)

<u>Volatile Compounds</u>

acrolein
acrylonitrile
benzene
carbon tetrachloride
chlorobenzene
1,2-dechloroethane
1,1,1-trichloroethane
1,1-dichloroethane
1,1,2-trichloroethane
1,1,2,2-tetrachloroethane
chloroethane
2-chloroehtylvinyl ether
chloroform
1,1-dichloroethene
trans-1,2-dichloroethene
1,2-dichloropropane
trans-1,3-dichloropropene
cis-1,3-dichloropropene
ethylbenzene
methylene chloride
chloromethane
bromomethane
bromoform
bromodichloromethane
fluorotrichloromethane
dichlorodifluoromethane
chlorodibromomethane
tetrachloroethene
toluene
trichloroethene
vinyl chloride

TABLE 3-17

SUMMARY OF PARAMETERS DETECTED IN GROUNDWATER FROM 42 PIEZOMETERS IN WAG 1 DURING SCOPING SURVEY BY KETELLE

Parameter	Units	Range in Concentrations
Bicarbonate	mg/L	55-496
Chloride	ug/L	3-130
Fluoride	ug/L	<1-1
Nitrate	ug/L	<5-12
Sulfate	ug/L	11-760
Aluminum	ug/L	0-16
Barium	ug/L	0-1
Calcium	ug/L	24-690
Iron	ug/L	0-12
Magnesium	ug/L	2-64
Manganese	ug/L	0-9
Sodium	ug/L	5-260
Silicon	ug/L	2-44
Strontium	ug/L	0-2
Zinc	ug/L	0-6
Gross alpha	Bq/L	0.02-2
Gross beta	Bq/L	0.13-86
Tritium	Bq/L	0.1-531
TOC	ug/L	2-8
Carbon tetrachloride	ug/L	<3-10
Chloroform	ug/L	<2-50
Dichlorobromomethane	ug/L	<2-5
1,1-Dichloroethene	ug/L	<3-88
Tetrachloroethene	ug/L	<4-108
Toluene	ug/L	<5-17
Methylene chloride	ug/L	<3-363
Trans-1,2-dichloroethene	ug/L	<2-183
Trichloroethene	ug/L	<2-246
Acetone	ug/L	102[a]
Carbon disulfide	ug/L	38[a]
pH	STD	6.9-11.9
Temperature	C	12.2-31.4
Conductivity	uMHOS/m	7.5-1930

[a] Only one well sampled for these parameters

Source: Voorhees (1987).

TABLE 3-18

CONCENTRATIONS OF PARAMETERS IN WELLS AROUND 3539-40[a]

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
2,4,5-TP Silvex	14	<0.01	<0.01	<0.01	0.0
2,4-D	14	0.06	<0.01	<0.014	0.0
Ag	14	<0.005	<0.005	<0.005	0.0
As	14	<0.01	<0.01	<0.01	0.0
Ba	14	<1.0	<1.0	<1.0	0.0
Cd	14	<0.002	<0.002	<0.002	0.0
Cl	14	17	5.2	8.2	1.7
Cr	14	0.032	<0.02	<0.021	0.0017
Endrin	14	<0.0002	<0.0002	<0.0002	0.0
F	14	<1.0	<1.0	<1.0	0.0
Fe	14	5.9	0.052	1.8	0.84
Fecal coliform[c]	14	0.0	0.0	0.0	0.0
Gross alpha[d]	14	0.52	0.03	0.23	0.0023
Gross beta[d]	14	2.0	0.081	0.74	0.01
Hg	14	<0.0001	<0.0001	<0.0001	0.0
Lindane	14	<0.002	<0.002	<0.002	0.0
Methoxychlor	14	<0.008	<0.008	<0.008	0.0
Mn	14	10	0.01	4.4	2.0
Na	14	220	4.8	26	31
NO_3	14	<5.0	<5.0	<5.0	0.0
Pb	14	1.2	0.02	0.10	0.17
pH[e]	98	13	6.5	7.6	0.29
Phenols	14	0.003	<0.001	<0.002	0.0004
Ra (Total)[d]	14	0.17	0.011	0.03	0.0007
Se	14	<0.005	<0.005	<0.005	0.0
SO_4	14	250	<5.0	<6.5	39
Specific conductance[f]	98	1.0	0.01	0.38	0.044
Temperature[g]	98	20	13	16	0.26
Total organic carbon	56	23	1.6	5.1	1.4
Total organic halides	56	0.093	<0.005	<0.005	0.0
Toxaphene	14	<0.005	<0.005	<0.005	0.0

[a] Source: Department of Environmental Management (1986)
[b] 95% confidence coefficient about the average.
[c] Units are colonies per 100 mL.
[d] Units are Bq/L.
[e] Value in pH units.
[f] Units are in mmhos/cm.
[g] Units are in °C.

TABLE 3-19

CONCENTRATIONS OF PARAMETERS IN WELLS AROUND 3524[a]

Parameter	No. of Samples	Concentration (mg/L) Max	Min	Av	95% cc[b]
2,4,5-TP Silvex	10	<0.01	<0.01	<0.01	0.0
2,4-D	10	<0.01	<0.01	<0.01	0.0
Ag	10	<0.005	<0.005	<0.005	0.0
As	10	<0.01	<0.01	<0.01	0.0
Ba	10	<1.0	<1.0	<1.0	0.0
Cd	10	<0.002	<0.002	<0.002	0.0
Cl	10	11	4.7	7.0	1.3
Cr	10	0.02	<0.02	<0.02	0.0
Endrin	10	<0.0002	<0.0002	<0.0002	0.0
F	10	<1.0	<1.0	<1.0	0.0
Fe	10	1.5	0.08	0.46	0.3
Fecal coliform[c]	10	14	0.0	1.4	2.8
Gross alpha[d]	10	52	0.011	7.8	0.29
Gross beta[d]	10	220	0.30	52	1.4
Hg	10	<0.0001	<0.0001	<0.0001	0.0
Lindane	10	<0.002	<0.002	<0.002	0.0
Methoxychlor	10	<0.01	<0.01	<0.01	0.0
Mn	10	4.0	0.07	1.3	1.0
Na	10	30	14	20	3.0
NO_3	10	<5.0	<5.0	<5.0	0.0
Pb	10	0.05	<0.02	<0.02	0.01
pH[e]	70	8.2	7.2	7.5	0.05
Phenols	10	0.002	<0.001	<0.0013	0.0
Ra (Total)[d]	10	0.037	<0.011	<0.015	0.0002
Se	10	<0.005	<0.005	<0.005	0.0
SO_4	10	100	19	52	21
Specific conductance[f]	70	0.49	0.03	0.23	0.02
Temperature[g]	70	22	8.8	16	0.78
Total organic carbon	40	3.8	1.1	2.4	0.22
Total organic halides	40	0.07	0.01	0.03	0.0
Toxaphene	10	<0.005	<0.005	<0.005	0.0

[a] Source: Department of Environmental Management (1986)
[b] 95% confidence coefficient about the average.
[c] Units are colonies per 100 mL.
[d] Units are Bq/L.
[e] Value in pH units.
[f] Units are in mmhos/cm.
[g] Units are in °C.

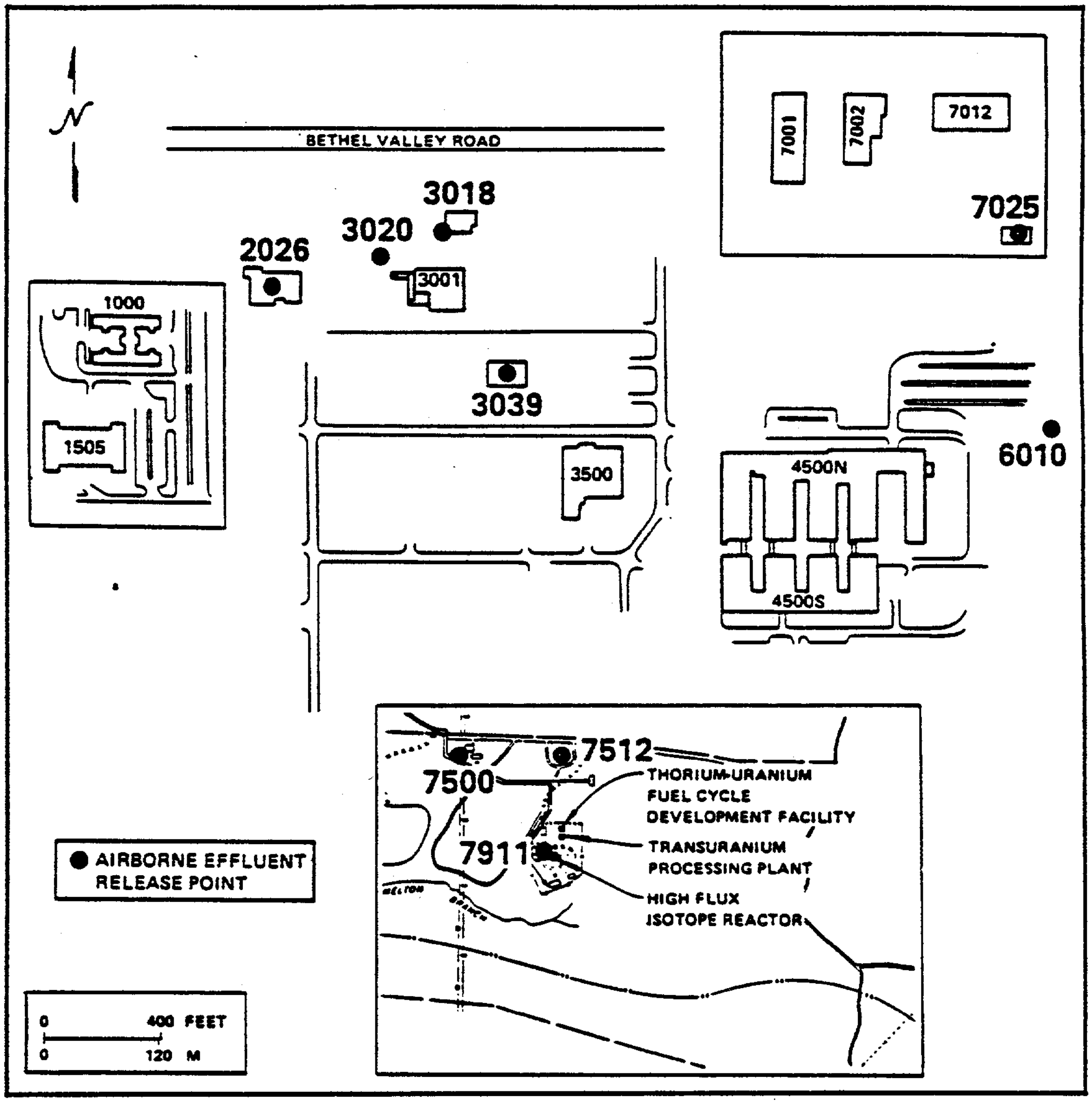
3.3.1.5 Air. Details of the gaseous and particulate emission control network at the Main Plant Area in WAG 1 are presented in various surveillance documents (e.g., Oakes et al., 1987) provided by Energy Systems. These documents provide detailed information on the air monitoring activities for the ORR conducted by the Department of Environmental Management, within the Environmental Compliance and Health Protection Division at ORNL.

Nearly 2,000 airborne discharge points at ORNL have been identified. Three major ventilation systems for the ORNL plant are cell ventilation, off-gas system, and lab hoods and individual vents. Major radioactive pollutants are particulates and gaseous radioisotopes of tritium, noble gases (xenon-132 and krypton-85), iodine, and radon.

ORNL policy is to decontaminate gaseous effluents insofar as practical at the source before they enter plant ventilation systems. Effluents are then filtered through roughing and high-efficiency particulate air (HEPA) filters to remove particulates through charcoal absorbers or chemical scrubbers to remove reactive gases. Prior to discharge, 99.9 percent of the particulates and 95 percent of the reactive gases are removed. Currently, there are four stacks in use near the Main Plant Area. Stack 3018 is no longer in service. Figure 3-20 shows the location of these stacks and Table 3-20 lists the stacks (Oakes et al., 1987). Stack 3039 is being upgraded to provide isokinetic sampling (Oakes et al., 1987). The cell ventilation system recently underwent a major overhaul to modernize the air emissions control network.

External gamma radiation measurements are made routinely to confirm that radioactive effluents from ORNL are not significantly increasing the levels above background. Figure 3-21 shows the locations near the Main Plant Area where external gamma radiation is

ORNL-DWG 87-8359



SOURCE: OAKES et al., 1987

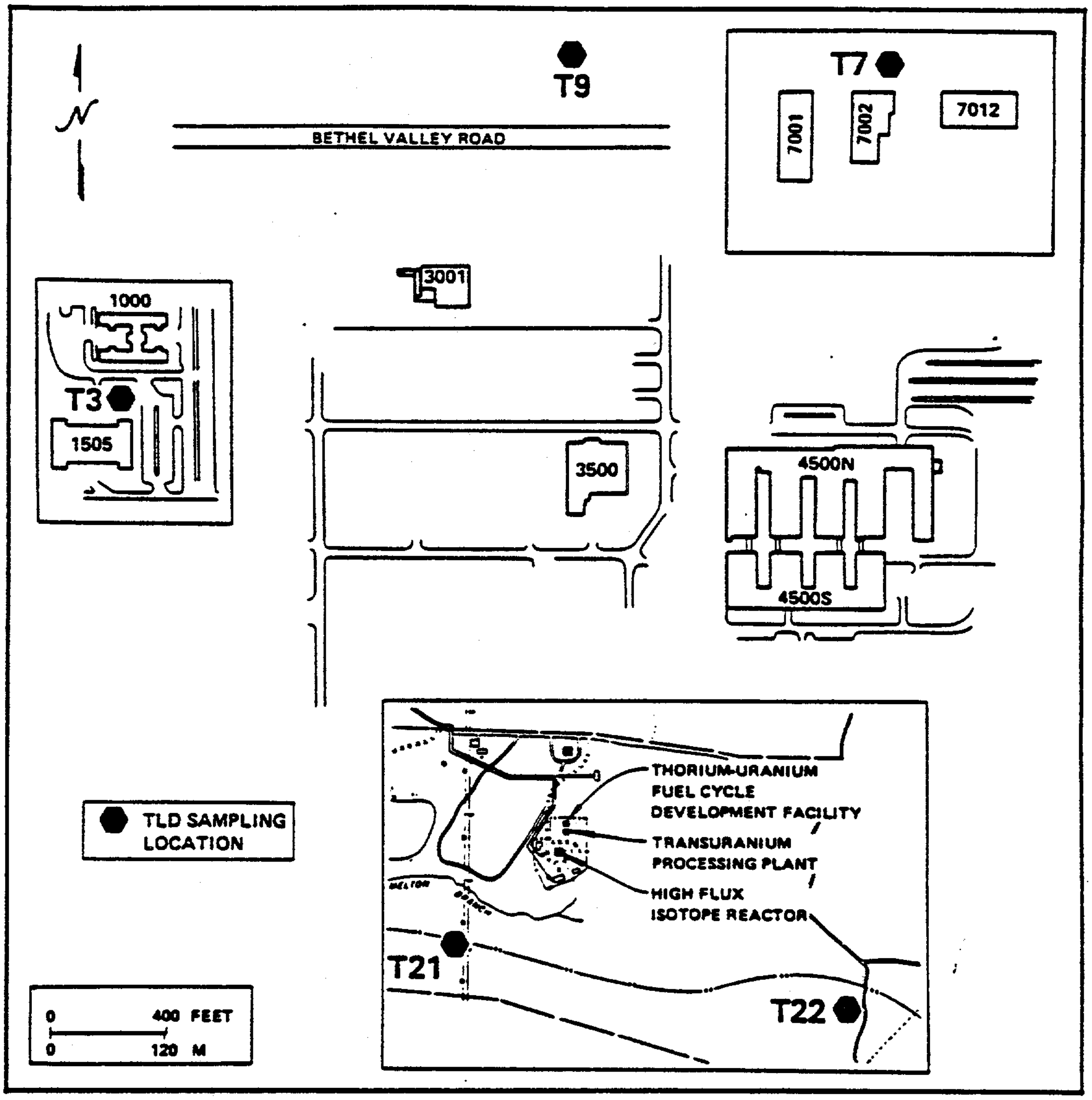
FIGURE 3-20
LOCATIONS OF SOURCES OF
AIRBORNE RADIOACTIVE EFFLUENTS AT ORNL

TABLE 3-20

STACKS NEAR THE MAIN PLANT AREA

ORNL Stack No.	Stack Service
3039	Provides service for most of ORNL activities
3020	Provides cell ventilation for the radiochemical processing plant, 3019
2026, 6010	Handles specific facilities and only very small quantities of activity

ORNL-DWG 87-83239



SOURCE: OAKES et al., 1987

FIGURE 3-21
LOCATIONS OF TLDs AROUND THE MAIN PLANT SITE

monitored. Table 3-21 (Oakes et al., 1987) presents the quarterly summaries of external gamma radiation from ORNL perimeter air monitoring (PAM) stations.

3.3.2 Corrective Actions

Corrective actions have been performed at many of the WAG 1 SWMUs. Brief summaries of the corrective actions known to have been performed are presented in Table 3-22 (ORNL, 1987a).

3.3.3 Remedial Action Technology Demonstrations and Research Projects

Data useful for risk and remedial alternatives assessments may be obtained from remedial action technology demonstrations and research projects completed, underway, or planned as part of Energy Systems' RAP. Demonstration and research projects at other DOE facilities on the ORR, such as the Y-12 Plant, may also be applicable.

Examples of RAP and other applicable projects include the following:

- In situ vitrification
- Dynamic compaction
- Trench grouting (particulate and polyacrylamide)
- Multilayer trench capping
- Surface water diversion structures
- Grout curtains
- French drains
- Heavy metal waste investigations (Y-12 Plant)
- Waste minimization strategies employed in previous characterization or remedial activities

TABLE 3-21

EXTERNAL GAMMA RADIATION MEASUREMENTS FROM TLDs AROUND THE MAIN PLANT SITE

April - June 1986

Location	No. of Samples[a]	uR/h[b]			
		Max	Min	Av	95% CC
3	3	14	11	13	2.2
9	3	16	12	13	2.6

a The number of samples indicates the number of months of data. Each month, individual dosimeters are averaged for each station.

b The background external gamma radiation, based on ORNL surroundings, is 10 uR/h (Oakes et al., 1987).

TABLE 3-22

CORRECTIVE ACTIONS AT WAG 1 SWMUs

SWMU No.	Corrective Action No	Corrective Action Yes	Description of Corrective Action(s)
1.1	x		
1.2	x		
1.3	x		
1.4	x		
1.5a		x	Some LLW lines have been replaced or modified.
1.5b		x	Some LLW lines have been replaced or modified.
1.5c		x	Some LLW lines have been replaced or modified.
1.5d		x	Some LLW lines have been replaced or modified. Leak was capped in 1985; soil removed only to make repairs.
1.5e		x	Some LLW lines have been replaced or modified. Leak was corrected in 1978; soil removed only to make repairs.
1.5f	x		
1.5g		x	Some LLW lines have been replaced or modified.
1.5h		x	Some LLW lines have been replaced or modified.
1.5i		x	Grass and soil dug up and replaced with clean dirt.
1.5j	x		
1.5k		x	Some LLW lines have been replaced or modified.

TABLE 3-22 (Continued)

SWMU No.	Corrective Action No	Corrective Action Yes	Description of Corrective Action(s)
1.5l		x	Excavation and repair of the leaking line extended from No. 1 pump cell to approximately 80 ft north of Building 3085 to the "Y" pit. Following repair of the leaks, a 6-in. concrete wall was poured on each side of the pipe and covered with 3/8-in. aluminum treadplate.
1.5m		x	Some LLW lines have been replaced or removed. Leaking line was abandoned and bypassed; contaminated soil was removed and backfilled with clean soil.
1.5n		x	Some LLW lines have been replaced or removed. Leaking line was repaired with an Adams clamp.
1.5o		x	Contaminated earth around line removed, concrete gallery floor was decontaminated by chipping; entire floor painted. Pipe trench, in SE corner of tank farm, cleaned up by removing contaminated soil.
1.5p		x	Some LLW lines have been replaced or removed.
1.5q		x	Some LLW lines have been replaced or removed.
1.5r		x	Some LLW lines have been replaced or removed.
1.5s		x	Some LLW lines have been replaced or removed.
1.5t		x	Some LLW lines have been replaced or removed.
1.5u		x	Ground has been paved. Removed 6 yd^3 of contaminated dirt.
1.5v	x		

TABLE 3-22 (Continued)

SWMU No.	Corrective Action No	Corrective Action Yes	Description of Corrective Action(s)
1.5w		x	Some LLW lines have been replaced or modified.
1.6		x	Some areas have been decontaminated; some soil was removed from contaminated areas.
1.7	x		
1.8	x		
1.9		x	Cleanup efforts (April 1974) included removing, cleaning, and rewelding the tank; documentation of contaminated soil removal is lacking.
1.10	x		
1.11		x	Some contaminated soil removed.
1.12	x		
1.13	x		
1.14	x		
1.15	x		
1.16	x		
1.17	x		
1.18	x		
1.19		x	Ponds were filled with clay and earth and covered with grass.
1.20		x	Facility upgrade in 1986. Removal of some contaminated soil.
1.21	x		
1.22	x		

TABLE 3-22 (Continued)

SWMU No.	Corrective Action No	Corrective Action Yes	Description of Corrective Action(s)
1.23a		x	Tank taken out of service because of leaks.
1.23b		x	Tank taken out of service because of leaks.
1.24a	x		
1.24b	x		
1.25a	x		
1.25b	x		
1.25c	x		
1.26a	x		
1.26b	x		
1.26c	x		
1.26d	x		
1.26e	x		
1.26f	x		
1.27		x	Tank taken out of service because of leak.
1.28		x	Tank taken out of service because of leak.
1.29	x		
1.30a		x	Tank taken out of service because of leak.
1.30b		x	Tank taken out of service because of leak.
1.31a	x		

TABLE 3-22 (Continued)

SWMU No.	Corrective Action No	Corrective Action Yes	Description of Corrective Action(s)
1.31b	x		
1.31c	x		
1.32	x		
1.33	x		
1.34	x		
1.35	x		
1.36	x		
1.37a	x		
1.37b	x		
1.37c	x		
1.37d	x		
1.38	x		
1.39a	x		
1.39b	x		
1.39c	x		
1.39d	x		
1.39e	x		
1.40	x		
1.41	x		
1.42a	x		
1.42b	x		
1.42c	x		

TABLE 3-22, Continued

SWMU No.	Corrective Action No	Corrective Action Yes	Description of Corrective Action(s)
1.43a	x		
1.43b	x		
1.44	x		
1.45a	x		
1.45b	x		
1.46		x	Fenced and grassed.
1.47	x		
1.48	x		
1.49	x		
1.50	x		
1.51	x		
1.52	x		
1.53	x		
1.54	X		

Source: ORNL (1987a).

- Techniques for screening for mercury, PCBs, and volatile organics in soil (Y-12 Plant), removal of mercury from water, and pilot survey of mercury levels in Oak Ridge
- Field evaluations of cement-based grouts and fabric liners
- Pilot studies for treatment of liquid containing low-level radioactivity

3.4 SUMMARY OF NATURE AND EXTENT OF ENVIRONMENTAL CONTAMINATION

All known information concerning the LLW leak and spill sites was summarized by Grimsby (1986a; 1986b). Not only does the report provide site specific information, but additional reference is made to the movement of the radionuclide contaminants into or along adjacent pipelines or drainage systems. This information has been plotted in Figure 3-22. Review of this figure illustrates the spread of radionuclide contaminants from the source area to other locations throughout the central portion of WAG 1. The predominant pathways are along the primary LLW pipelines and adjacent storm and sewer drains with flow in all directions. Discharge has been noted to occur in all streams within WAG 1.

While the leaks from both the tanks and transfer lines have been assumed to be principally composed of radionuclides, it is evident that the potential for similar widespread metal and organic contaminants at the leak sites exists. The initial site characterization scoping efforts outlined for the WAG 1 field sampling effort (Section 3.5) will utilize the presence of the radionuclide and organic contaminants to estimate the area of contamination.

The environmental samples that have been collected within WAG 1 are presented in Table 3-23. Specific sampling locations are shown in Figures 3-9a, 3-15a, 3-15b, and 3-15c, and in A3-1 in the Field Sampling Plan. None of these samples have been analyzed for the complete TCL complement; therefore, the full

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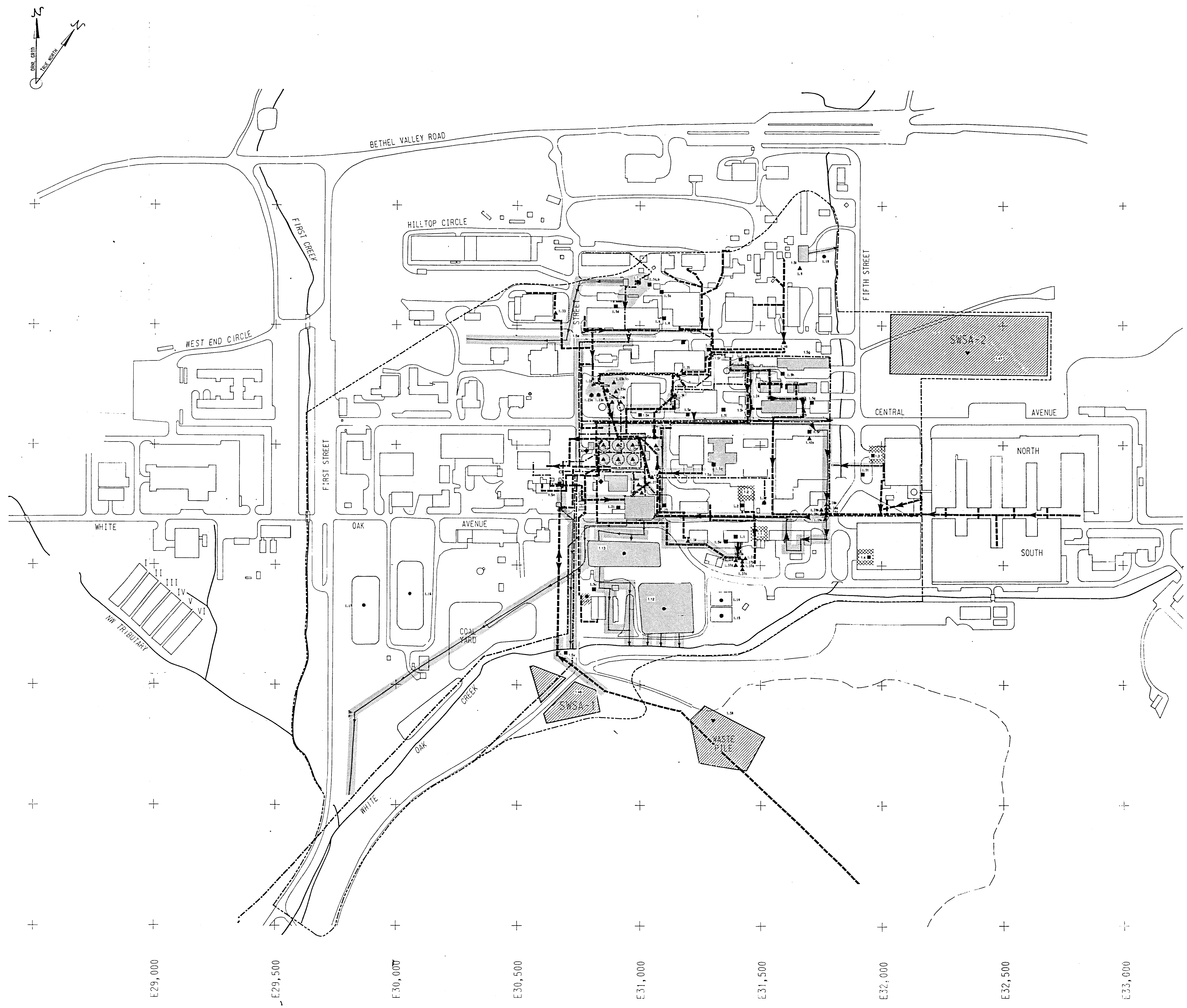

NOTES

1. TOPOGRAPHIC AND SITE SPECIFIC INFORMATION PROVIDED BY ENERGY SYSTEMS.
2. ORNL GRID
3. SWMU'S ARE APPROXIMATELY LOCATED.
4. AREAS OF CONTAMINATIONS ARE ESTIMATED BASED ON INFORMATION IN BOEGLY et al 1987, GRIMSLY, 1986a, AND GRIMSLY, 1986b.

INACTIVE LLW LINE
LLW WASTE SYSTEM
SANITARY OR STORM SEWER
CONTAMINATED AREAS ASSOCIATED WITH LLW / SYSTEM
MERCURY SPILLS
OTHER CONTAMINATED AREAS

LEGEND

BUILDING
PAVED ROADS
GRAVEL ROADS
FENCE
STREAM
WAG 1 BOUNDARY

SOLID WASTE MANAGEMENT UNITS

▲ COLLECTION & STORAGE TANK
▼ LAND DISPOSAL FACILITY
◆ WASTE TREATMENT FACILITY
■ LEAK OR SPILL SITE
● BASIN / POND
SWMU NUMBER

BECHTEL NATIONAL INC.
OAK RIDGE, TENNESSEE

FIGURE 3-22
AREAS OF RADIOLOGICAL / CHEMICAL CONTAMINATION WITHIN WAG 1

3-110

JOB NO.	DRAWING NO.	REV.
19118		

19118 E22W9802.DGN

34 X 44

#139

TABLE 3-23

INFORMATION MATRIX INDICATING MEDIA-SPECIFIC DATA ON CONTAMINANT CONCENTRATIONS IN WAG 1

Media	Location[a]	Radionuclide Constituents			Organics	Inorganics	Mercury	Section in WAG 1 RI Plan	Source
		Alpha	Beta	Gamma					
Groundwater[b]	FSP A3-1 (800-830)	X	X	X	(TOC&TOX)	X	X	3.3.1.4	MMES (1989)
Groundwater[c]	Figure 3-9a	X	X	X				3.3.1.4	Hall (1989)
Groundwater[d]	FSP A3-1 (500&600)	X	X	X	(Selected volatile compounds)	X		3.3.1.4	Ketelle (1986)
Groundwater[b]	FSP A3-1 (870-890)	X	X	X	(TOC&TOX)	X	X	3.3.1.4	DEM (1986); DEM (1989)
Soils	Figure 3-9a	X	X	X				3.3.1.2	Huang, et al. (1984)
Soils	Figure 3-9a	X	X	X				3.3.1.2	Oakes and Shanks (1977)
Soils	Figure 3-9a	X	X	X				3.3.1.2	Oakes (1985)
Soils	Figure 3-9a	X	X	X		EP-Tox		3.3.1.2	Williams, et al. (1987)
Soils	Figure 3-9a						X	3.3.1.2	Oakes (1983)
Surface Water[e]	Figures 3-12, 3-13, 3-14	X	X	X	Selected	Selected		3.3.1.3	NPDES Permit
Surface Water	Figure 3-15a						X	3.3.1.3	Taylor (1989)
Sediments	Figure 3-15a	X	X	X		X	X	3.3.1.3	Cerling and Spalding (1981) Cerling and Huff (1986) Morrison and Cerling (1987)
Sediments	Figure 3-15a						X	3.3.1.3	Oakes (1983)
Sediments	Figure 3-15b						X	3.3.1.3	Taylor (1989)
Sediments	Figure 3-15a	X	X	X			X	3.3.1.3	Cutshall (1985)
Sediments	Figure 3-15a	X	X	X				3.3.1.3	Daniels (1989)

(1) Location refers to the figure and site numbers that correspond to the media.
(2) From stainless steel RCRA quality monitoring wells.
(3) From dry wells associated with the inactive tanks.
(4) From PVC piezometer wells.
(5) From NPDES permitted point discharges.

Note: "X" in the contaminant column indicates analytical data is present for that media; blank indicates no analyses undertaken.

extent of the identified source contaminants in the WAG 1 environment has not been identified. This is necessary to establish the contaminants of concern that will feed into the baseline health assessment.

3.5 CONCEPTUAL MODEL OF WAG 1

WAG 1 is a large research and development facility comprised of research laboratories, isotope production facilities, associated administrative and support facilities, a number of radiological process impoundments, and chemical waste basins, a coal fired heating plant, and all associated process, heating and ventilation, water and electrical, waste lines. At a minimum, the upper 10 ft of soil underlying the facility has been thoroughly disrupted by construction activities over the last 45 years. Pipe trenches criss-cross the site from one end to the other in all directions commonly paralleling streets. The pipelines themselves are located at various depths, generally dependent upon function.

The facility is located in Bethel Valley, underlain by rocks, primarily limestone, of the Chickamauga group, which strike approximately N55°E with an average dip of 40°SE. Haw Ridge southeast of WAG 1 is underlain by the Copper Creek thrust fault, which places the Rome Formation in fault contact with the Chickamauga. Chestnut Ridge to the northwest is underlain by rocks of the Knox Group. The surface of WAG 1 is drained by White Oak Creek and its tributaries, First and Fifth Creeks.

To the northwest of Central Avenue most buried pipelines and building basements are above the water table; southeast of Central Avenue they are below water table.

Waste sources in WAG 1 can be subdivided into primary sources, which include tanks, process waste lines, impoundments and solid waste storage areas (burial grounds). Secondary sources include such things as surface spills and contaminated soils. Waste categories are considered to be liquid and solid with contaminant constituents identified as radionuclides, organics, and inorganics. While heavy metals are considered the primary inorganic contaminants, other constituents, such as NO_3, must be considered because of their prominence in process wastes.

Transport varies with the waste material of concern and the physical setting within the WAG. Leaks or spills in areas where the water table is deeper than pipe trenches or basements are considered to flow downslope in more permeable backfill around pipes via the path of least resistance (highest permeability). Where water table is below the overburden-bedrock interface there will likely be only limited geologic influence on contaminant migration; most of the controls are anthropogenic. Where pipe trenches and building basements are below the water table, contaminant flow will be controlled by the more permeable material in pipe trenches but dispersion and diffusion will lead to a broader contaminant distribution. Pipe trenches may cause contaminant migration in directions other than would be expected by water table gradients. The bulk of shallow groundwater flow in WAG 1 is to discharge points in surface water bodies. Preliminary data suggests limited downward flow of water. Gradients in deeper wells suggest potential for upward flow in the bedrock flow system beneath WAG 1.

The influence of the anthropogenic structures within WAG 1 on the spread of contaminants from the primary sources implies that some points of potential exposure may not be well defined at present. The magnitude of the exposure resulting from these transport routes will be evaluated as part of the baseline health assessment. The potential human environmental exposure routes to the receptor, as described in the baseline health assessment (Section 4.2), include direct radiation and ingestion and inhalation of contaminants.

4.0 INITIAL EVALUATION

In Section 3.0, data pertaining to site physical characteristics and site contamination were reviewed. This section identifies the specific data types necessary to achieve the project objectives.

A re-evaluation of data presented in the original WAG 1 RI of December 1987 and the new information summarized in Sections 3.2 and 3.3 of this report have led to a reassessment of the field sampling activities proposed for WAG 1. In addition to the data re-evaluation, individual SWMUs have been grouped into operable units (Section 4.1), the exposure scenarios for the baseline health assessment have been identified (Section 4.2). The use of operable units will provide a clearer focusing on potential problems. These two sections better define the conceptual framework for determining data needs than in the original December 1987 RI Plan.

4.1 PRELIMINARY IDENTIFICATION OF OPERABLE UNITS

Response actions for hazardous waste sites may be addressed in operable units under the National Contingency Plan (NCP) and the Superfund Amendments and Reauthorization Act of 1986 (SARA). An operable unit is defined as "a discrete part of the entire response action that decreases a release, threat of release, or pathway of exposure." Operable units may be established either for removal or for remedial actions and must be consistent with "achieving a permanent remedy" [40 CFR 300.68(c)].

For large, complex sites, such as WAG 1, analysis and evaluation of problems may readily be addressed by dividing the site into smaller more manageable units referred to as operable units. The identification of operable units will provide a means to focus on specific potential problems. In WAG 1, operable units will consist of groupings of contaminant sources and/or SWMUs.

During the RI/FS process, each operable unit will undergo a thorough investigation. As the RI/FS progresses, operable units will be refined. The operable units identified will be used as the basis for a planning effort in which potential remedial alternatives and overall site remedies will be identified in order to:

- Assess additional data needs during the Phase II RI,
- Determine the potential threat to human health in a human health assessment,
- Identify applicable or relevant and appropriate requirements,
- Plan for the potential remedial alternatives and overall site remedies, and
- Set priorities among the potential problems so that the more urgent ones and those for which data are more readily available may receive a quicker response than others.

4.1.1 Process for Identifying Operable Units

The initial identification of operable units in WAG 1 was based on the need for a methodical evaluation of the site problems. Each of the operable units is discrete and easily identifiable to the extent possible for such a complex site. Table 4-1 identifies the operable units in WAG 1 along with the individual SWMUs comprising the unit.

The following criteria were used for identifying the operable units in WAG 1:

- Media
- Reasonable size and complexity
- Physical or hydrological relationships, and
- Immediacy of potential hazard

The following section addresses the use of these criteria in selecting operable units for WAG 1.

TABLE 4-1

WAG 1 OPERABLE UNITS

Operable Unit (OU)	SWMUs Comprising the OU
Groundwater	
o Shallow (stormflow)	
o Deep (water table)	
Sediments	
Soils	
o 3019 area	1.5a-1.5e, 1.6, 1.7, 1.8
o 3085 area	1.5l and 1.9
o 3000 area	1.5f-1.5l, 1.5m, 1.22
o 3500 area	1.5o-1.5t, 1.5w, 1.20, 1.21, 1.62, 1.63
o Process area	1.5n, 1.5u, 1.5v
o Hg areas	1.1-1.4
Tanks	
o Inactive	1.23a-b, 1.24a-b, 1.25a-b, 1.26a-f, 1.27, 1.28, 1.29, 1.30a-b, 1.31a-c, 1.32, 1.56a-b
o Active	1.33-1.36, 1.37a-d, 1.38, 1.39a-e, 1.40, 1.41, 1.42a-c,
Impoundments	
o Radiological Process	1.11, 1.12, 1.13, 1.14, 1.15, 1.19
o Chemical/Sewage Basins	1.16, 1.17
Solid Waste Storage Areas	1.46, 1.47, 1.58

The first step in the identification of operable units in WAG 1 was to list the "waste media." The "waste media" includes obvious physical features such as tanks, waste storage and accumulation areas, and solid waste storage areas as well as the soils, sediments, and liquid media. The radiological ponds and impoundments seemed clearly appropriate as an operable unit. However, groundwater may be hydraulically connected with impoundment liquids and leachate from the solid waste storage areas and contaminated soils. Similarly, sediments have been deposited from runoff over the impoundments, waste storage and accumulation areas, contaminated spill areas, and solid waste storage areas. Surface water may become contaminated from groundwater influx and leaching from sediment from various SWMUs. Therefore, the three environmental media--sediments, surface water, and groundwater--are considered as operable units with no direct SWMUs associated with them. The contamination from the various SMWUs has contacted each of the three media and created a new contaminant source. Because of the complexity of WAG 1, some overlap of the operable units is inevitable.

The operable units in WAG 1 were also assessed for reasonable size and complexity. Some of the media is affected by several operable units and cannot be completely segregated. The identified operable units are also of an optimal working size to aid in the RI/FS process. The identification of too many operable units could lead to fragmenting the investigation process.

The operable units were also identified for a part or parts of WAG 1 that are physically or hydrologically related. The SWMUs were grouped into operable units based on the similarities that might cause the SMWUs to be treated in a like-manner or combined with other SWMUs for potential remediation. These similarities included geographic location, hydrological connections, process and/or functional equivalencies, and the nature of potential contamination. Media that have different physical characteristics but that are presently mixed or so closely related that any change in one affects the other are logically addressed in one operable unit.

In defining operable units, consideration was given to the immediacy of potential hazards to public health posed by the various media. If two similar media present very different degrees of hazard, they were addressed as separate operable units. An example of this is the difference between the potential problems posed by possible contamination in the shallow groundwater as compared with the possible contamination in deep groundwater in WAG 1. The contamination in the shallow groundwater might present a more immediate problem than in deep groundwater. The confirmation of the contamination in the latter would require substantial remedial investigation and the levels of contamination could be expected to be lower than those in the shallow groundwater. By contrast, contamination in the shallow groundwater might require a quicker response action.

The designation and/or composition of the operable units may be refined as data from the first phase of the WAG 1 RI is evaluated. Some SWMUs may prove to be hydrologically connected to units in a manner that is not obvious at present.

4.2 PRELIMINARY BASELINE HEALTH ASSESSMENT PROCESS

One of the primary objectives of the WAG 1 FSP will be to collect sufficient data to conduct a baseline health assessment. A baseline assessment is an evaluation of the potential threat to human health in the absence of any remedial action (no action alternative). It provides the basis for determining whether or not corrective measures are necessary and the justification for performing corrective measures.

WAG 1 is a complex site consisting of various degrees of contaminant releases. To efficiently characterize WAG 1, the investigation will be conducted in phases. Each phase will be built on the findings and conclusions of the previous phase. Several sampling phases will be needed to complete the preliminary baseline health assessment.

The components of the baseline health assessment include: the identification of exposure scenarios, determination of exposure point concentrations, identification of applicable or relevant and appropriate requirements (ARARs), and a risk estimate if ARARs are not available for all the contaminants of concern. The guidance that will be followed in developing the baseline health assessment is the RI/FS Guidance (EPA, 1988b), the Superfund Public Health Evaluation Manual (EPA, 1986), and the CERCLA Compliance With Other Laws Manual (EPA, 1988a).

4.2.1 Exposure Scenarios

An exposure scenario is comprised of a source, pathway, and receptor. The pathway components include a mechanism of contaminant release, an environmental transport medium, and a likely route of human intake or exposure. To be considered as a potential exposure scenario, all components of the source-pathway-receptor scenario must be present. The potential exposure scenarios have been identified for WAG 1 and are presented in Figure 4-1.

Sources

Sources in WAG 1 consist of collection and storage tanks, leak/spill sites and contaminated soils, ponds and impoundments, waste treatment facilities, and solid waste storage areas. Currently, there are 92 SWMUs identified within WAG 1. It is not the intent of the baseline risk assessment to characterize the release and assess the risk from every SWMU. Sources may be grouped together into operable units to assess the potential threat to human health.

PATHWAY—SEDIMENTS

SOURCE	• SWMUs
POTENTIAL RELEASE MECHANISM	CONTAMINATED SEDIMENTS GENERATED BY: • PRECIPITATION - CAUSED EROSION • FLOODING • ON-SITE ACTIVITY
TRANSPORT MEDIUM	• SEDIMENTS
POTENTIAL HUMAN EXPOSURE ROUTE	POTENTIAL EXPOSURE CAUSED BY: • DIRECT RADIATION • INGESTION VIA BIOTA
POTENTIAL RECEPTORS	• RECREATIONAL USER • INTRUDER INTO THE WASTE

PATHWAY—SURFACE WATER

SOURCE	• SWMUs
POTENTIAL RELEASE MECHANISM	CONTAMINATED SURFACE WATER GENERATED BY: • CONTAMINATED SOIL CONTACT • GROUNDWATER DISCHARGE
TRANSPORT MEDIUM	• SURFACE WATER
POTENTIAL HUMAN EXPOSURE ROUTE	POTENTIAL EXPOSURE CAUSED BY: • INGESTION • INGESTION VIA BIOTA
POTENTIAL RECEPTORS	• RECREATIONAL USER • INTRUDER INTO THE WASTE

CONTINUED

FIGURE 4-1
PRELIMINARY WAG 1 HUMAN EXPOSURE PATHWAYS

4.3 0782.1

PATHWAY—GROUNDWATER

SOURCE	• SWMUs
POTENTIAL RELEASE MECHANISM	CONTAMINATED GROUNDWATER GENERATED BY: • CONTAMINATED SOIL CONTACT • SURFACE WATER INFILTRATION
TRANSPORT MEDIUM	• GROUNDWATER
POTENTIAL HUMAN EXPOSURE ROUTE	POTENTIAL EXPOSURE CAUSED BY: • INGESTION • INGESTION VIA BIOTA
RECEPTORS	• INTRUDER INTO THE WASTE

PATHWAY—SOIL

SOURCE	• SWMUs
POTENTIAL RELEASE MECHANISM	CONTAMINATED SOIL GENERATED BY: • SURFACE SPILLS/OVERFLOWS • SUSPENDED AIR PARTICLES • SURFACE RUNOFF
TRANSPORT MEDIUM	• IN-PLACE SOIL
POTENTIAL HUMAN EXPOSURE ROUTE	POTENTIAL EXPOSURE CAUSE BY: • INCIDENTAL INGESTION • INGESTION VIA BIOTA • DIRECT RADIATION
POTENTIAL RECEPTORS	• BOUNDARY RECEPTOR • ORNL EMPLOYEE • RECREATIONAL USER • INTRUDER INTO THE WASTE

CONTINUED

FIGURE 4-1
(Continued)

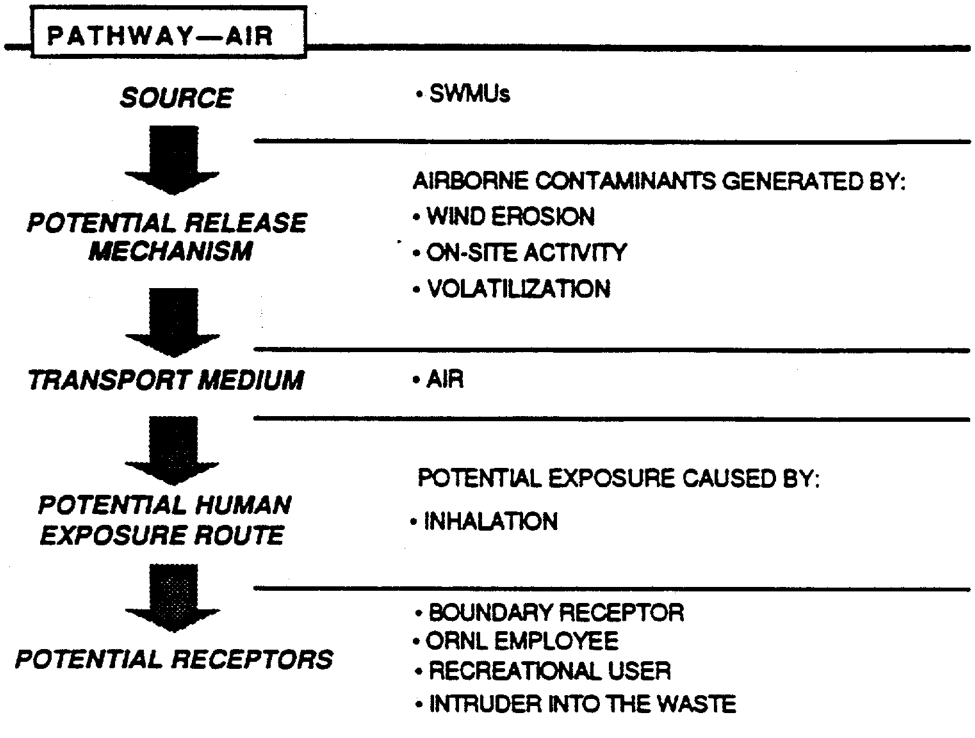

FIGURE 4-1
(Continued)

Pathways

The identified environmental media pathways in WAG 1 consist of soil, air, sediments, groundwater, and surface water. Dependent upon the source, there are several potential release mechanisms for each media. The potential release mechanisms for each pathway are identified in Figure 4-1. All the release mechanisms may not be present for every SWMU; however, all the potentially prominent mechanisms have been presented.

Similarly, the potential human environmental exposure routes vary according to the transport medium and receptor. The potential human environmental exposure routes for WAG 1 receptors and media are presented in Table 4-2. These exposure routes will be quantitatively assessed in the baseline public health evaluation. Other exposure routes, which have not been identified, may be insignificant when compared to the effect from these identified exposure routes. If the field characterization identifies other potentially significant exposure routes, they will be addressed in the baseline public health evaluation.

Receptors

Potential receptors have been identified for WAG 1. The receptors and the exposure pathways are identified for time periods based upon the following assumptions concerning WAG 1 operations:

- Institutional controls are as follows:
  - ORNL remains operational for the next 30 years
  - Post-operational controls are in place for 100 years
  - After 130 years, the site is uncontrolled (i.e., released for unrestricted use)
- All facilities are decommissioned prior to 130 years, all above ground facilities are removed and all below ground facilities remain.

TABLE 4-2

POTENTIAL HUMAN ENVIRONMENTAL EXPOSURE ROUTES FOR WAG 1 RECEPTORS

POTENTIAL RECEPTORS	PATHWAYS				
	SOIL	AIR	SEDIMENTS	GROUNDWATER	SURFACE WATER
Boundary Receptor	o Direct Radiation (R)	o Inhalation (R,C)	-	-	-
ORNL Employee	o Direct Radiation (R)	o Inhalation (R,C)	-	-	-
Recreational User	o Direct Radiation (R) o Incidental Ingestion (R,C) o Indirect Ingestion via Biota (R,C) (1)	o Inhalation (R,C) o Indirect Ingestion via Biota (R,C) (1)	o Direct Radiation (R)	-	o Indirect Ingestion via Biota (R,C) (1)
Intruder into the Waste	o Direct Radiation (R) o Incidental Ingestion (R,C) o Indirect Ingestion via Biota (R,C) (1)	o Inhalation (R,C) o Indirect Ingestion via Biota (R,C) (1)	o Direct Radiation (R)	o Ingestion (R,C) o Indirect Ingestion via Biota (R,C) (1)	o Indirect Ingestion via Biota (R,C)(1) o Ingestion (R,C)

R = Assessed for radionuclides components
C = Assessed for chemical components
1 = Refers to human ingestion of biota which have consumed contaminated environmental media

The use of a 130-year control period allows for radioactive decay of some of the isotopes prior to release of the site for unrestricted use. The potential receptors identified for the periods of institutional control are boundary receptors, ORNL employees, recreational users, and intruders into the waste. Table 4-3 identifies the periods of institutional control and the potential receptors for each period. For the purposes of exposure scenario identification, the following definitions apply to receptors:

- Boundary receptors are defined as human receptors during the controlled operational and post-operational periods who engages in an activity outside the WAG 1 boundary. The potential human exposure routes that have been identified for the boundary receptor include direct exposure to contaminated soil and inhalation of contaminated air.

- During the controlled operational period, ORNL employees are human receptors who are non-radiation protection workers; these include maintenance workers and office personnel who may occasionally be exposed to contaminants from maintenance activities and daily routes to and from work places on WAG 1. During the controlled post-operational period, ORNL employees are human receptors who are radiation protection workers; these include decontamination workers who may be exposed from contaminants during decontamination/decommissioning activities. The potential human exposure routes that have been identified for the ORNL employee include direct exposure to contaminated soil and inhalation of contaminated air.

- Recreational users are human receptors during the uncontrolled period; these include picnickers and hunters who may be exposed from contaminants on WAG 1. The potential human exposure routes that have been identified for the recreational user include incidental ingestion of contaminated soil, inhalation of contaminated air, direct exposure to contaminated soil and sediments, and consumption of contaminated flora and/or fauna.

- Intruders into the waste are human receptors during the uncontrolled period; these include residents, well drillers and construction workers who reside, drill or excavate anywhere in the WAG 1 contaminated zone. The potential human exposure routes that have been identified for the resident include direct exposure and incidental ingestion of contaminated soil, inhalation of contaminated air, direct exposure to contaminated sediments, and ingestion of

TABLE 4-3

POTENTIAL WAG 1 RECEPTOR SCENARIOS

POTENTIAL RECEPTORS	PERIOD OF INSTITUTIONAL CONTROL				
	CONTROLLED (Operational) 0 - 30 YRS		CONTROLLED (Post-Operational) 30 - 130 YEARS		UNCONTROLLED(1) (Non-Operational) > 130 YEARS
	ON-WAG	OFF-WAG	ON-WAG	OFF-WAG	
Boundary Receptor		X		X	
ORNL Employee	X(2)		X(3)		
Recreational User					X
Intruder into the Waste					X

Key: X = Potential WAG 1 Receptor Identified for Institutional Control Period
1 = WAG 1 Area in uncontrolled period, no WAG boundaries exist
2 = Non-Radiation Protection Worker
3 = Radiation Protection Worker

contaminated groundwater and surface water. The intruder into the waste may also consume flora which have been grown in contaminated soil and irrigated with contaminated water, and fauna which have consumed contaminated biota and contaminated water.

Data Needs

Data are needed to define source areas of contamination, the potential pathways of migration, and the associated exposure point concentrations to the extent necessary to determine whether, or to what extent, a threat to human health exists. The data needs identified in this FSP will be sufficient to perform an initial baseline public health evaluation.

Achieving the broad risk assessment objective associated with WAG 1 requires that several complicated and interrelated activities be performed, each having identified objectives. These objectives include characterizing the site with respect to the environmental setting and the nature and extent of the problem. The expression of these objectives is the first step toward the development of a cost-effective and efficient data collection program. The field sampling plan is established from the identification of the data needs for the baseline health assessment. Table 4-4 identifies the data needs for the performance of baseline health assessments and the corresponding sections within the Field Sampling Plan to meet these objectives. The analytical levels (Table 4-5) needed to achieve the stated objectives is also shown.

4.2.2 Environmental Analysis

Biota, which were identified as environmental transport media for the human exposure assessment, may also be considered receptors. Exposure pathways for WAG 1 that might impact the biota are identified as follows:

TABLE 4-4

CORRELATION OF DATA NEEDS WITH FIELD SAMPLING ACTIVITIES REQUIRED TO COMPLETE THE WAG 1
SITE CHARACTERIZATION AND BASELINE HEALTH ASSESSMENT

Data Needed	Method	Analytical Level	Field Sampling Plan	Section	Data Quality Objective
DETERMINE NATURE AND EXTENT OF CONTAMINATION (SITE CHARACTERIZATION)					
Radionuclide soil contaminant screening	Radiation walkover survey inside the WAG boundary (except buildings and obstructions) and outside the WAG boundary to define areas of contamination.	Level I	Radiation Walkover Survey	A2.2	Measure beta-gamma levels to determine where radionuclide contamination exists and relative levels. Used to locate soil sample locations and exposure estimate measurements.
Chemical soil contaminant screening	X-ray fluorescence in areas where known metal contamination occurred.	Level II	X-Ray Fluorescence	A2.5	Measure heavy metal surface contamination to determine where it exists and to what extent. Used to locate oil sample locations.
	Electromagnetic survey (EM-31) in SWSA 1, SWSA 2, and waste pile area (SWMU 1.58).	Level I	EM-31	A2.4	Measure ground conductivity used to delineate the areal extent of solid wastes.
Presence of organic contaminants in water	Headspace gas analysis in up to 50 stainless steel compliance wells and up to 101 piezometers.	Level II	Headspace Gas Analysis	A3.2	Measure volatile organic contaminants to determine where it exists.
Groundwater contaminant screening	Groundwater sampling in the existing monitoring well network and piezometers.	Level I-II	Groundwater Sampling	A3.5	Measure organics, beta/gamma, and metals to determine presence, range, and concentrations of contaminants.
	Evaluation of existing sump and dry well data and additional sampling, if necessary.	Level I-II	Evaluation and Upgrade of Existing Wells, Drywells, and Sumps	A3.3	Provide data on the presence of radionuclides and metals in groundwater to determine presence and range.
Creek channel sediment screening	Sampling in 14 locations including White Oak Creek and First Creek.	Level I-II	Creek Channel Sediments	A4.2	Measure organics, beta/gamma, and metal to determine presence, range, and contaminant concentrations.
Creek contaminant screening	Sampling at 8 locations.	Level I-II	Creek Sampling	A5.2	Measure organics, beta/gamma, and metals to determine presence, range, and contaminant concentrations.
Impoundment sediment screening	Random sampling at 3 locations.	Level I-II	Impoundment Sediments	A4.3	Measure organics and beta/gamma to determine presence, range, and contaminant concentrations.

TABLE 4-4 (Continued)

Data Needed	Method	Analytical Level	Field Sampling Plan	Section	Data Quality Objective
SUPPORT OF BASELINE HEALTH ASSESSMENT AND ADDITIONAL SITE CHARACTERIZATION					
Groundwater contaminant concentrations, flow rates and groundwater geochemistry	Sampling groundwater wells during a seasonal low water table, storm event, high water table, and base condition.	Level I-V	Groundwater Sampling	A3.5	Measure field parameters, chemicals, and radionuclides to determine migration potential and contaminant concentrations to potential receptors.(1)
Water table levels	Measurement of water levels prior to well development and once during each of the two groundwater sampling events.	Level I	Water Level Monitoring	A3.6	Determine water potential streamlines and relationship between groundwater and surface water flow regimes.
Deep corehole analysis consisting of water samples, hydraulic head analysis, log analysis	Analysis of five existing coreholes; and if useful, two additional transects up to 5 coreholes each will be installed.	Level I-V	Deep Coreholes Transect	A3.7	Measure field parameters, chemicals, and radionuclides present in water and gamma log the boring. Perform acoustic logging to identify fracture zones. Packer permeability testing, contaminant testing, and borehole geophysics will be employed to determine the interrelationship between the shallow (overburden) and the deeper (bedrock) flow systems.
Creek channel sediment contaminant concentrations	Sampling in 14 locations including White Oak Creek and First Creek.	Level I	Creek Channel Sediments	A4.2	Measure field parameters, chemicals, and radionuclides in the sediments. Will be used to identify contaminants, concentrations, and extent of contaminants that have migrated to the creeks.
Creek velocities	Evaluate existing flow monitoring measurements made on WOC and First Creek; install weir on Fifth Creek and staff gauge, other locations will utilize a graduated cylinder/stopwatch method or current velocity meter.	Level I	Creek Flow	A5.1	Data used in risk assessment for contaminant transport evaluation.
Creek contaminant concentrations and field analysis	Sampling of 8 locations corresponding with the groundwater sampling, once each during high and low water tables, and during a storm event at both high and low water tables.	Level I-V	Creek Sampling	A5.2	Measure field parameters, chemicals, and radionuclides in the creeks. Will be used to identify contaminants, concentrations, and extent of contaminants that have migrated to the creeks. Will also be used to determine the relationship between groundwater and surface water flow regimes.

TABLE 4-4 (Continued)

Data Needed	Method	Analytical Level	Field Sampling Plan	Section	Data Quality Objective
Soil contaminant concentrations and parameters	Sampling based on results from radiological walkover, x-ray fluorescence survey, and well headspace gas analysis; specifically, sample is based on the area reading greater than 3x background for radiation, positive x-ray fluorescence response, and organic analysis results.	Level I-V	Soils I	A6.1	Measure field parameters, chemicals, radionuclides, and engineering properties to identify contaminant concentrations and extent. Used in the risk assessment to determine the potential risk to human via the soil medium.
Soil contaminant concentrations along anthropogenic structure	From nondestructive groundwater analyses, trenches will be located for route tracking; in this area, soil samples will be collected using either a hand auger or a truck-mounted auger.	Level I-V	Soils II	A6.2	Use data to determine the extent of contaminant transport via the anthropogenic structures to identify contamination extent, major migration routes, and subsequent contaminant sources.
Specific contaminants and properties associated with SWMUs or operable units	After gathering and analyzing data from all previous sampling and investigations, locations will be determined.	Level I-V	Soils III	A6.3	Measure field parameters, chemicals, radionuclides, and engineering properties to identify contaminant concentrations and extent. Used in the risk assessment to determine the potential risk to humans via the soil medium.
Personnel exposure information for radionuclides	A combination of PIC/GM instruments, PIC long-term recordings, and TLD stations will be used to establish radiation field characteristics.	Level I-II	Personnel Exposure Information	A2.3	Measure the collective dose to the public from external irradiation to be used in the risk assessment.
Receptor location information	Sample areas around SWMUs to obtain a range of contaminant concentrations.	Level I-V	Groundwater Sampling Creek Channel Sediment Sampling Impoundment Sediment Sampling Creek Sampling	A3.5 A4.2 A4.3 A5.2	Determine receptor locations.

(1) Field parameters include temperature, pH, specific conductivity, Eh, and beta/gamma scan. Chemicals include TCL, miscellaneous parameters, and ICP metals and appropriate organics. Radionuclides include gross alpha and beta, gamma spectroscopy, and alpha and beta emitting isotopes.

TABLE 4-5

ANALYTICAL LEVELS

LEVEL	DESCRIPTION
I	Field screening using portable instruments. Results are often not compound specific and not quantitative, but they are available in real time. This is the least costly of the analytical options. Instruments may not respond to all compounds and may not be able to identify compounds. If the instruments are calibrated properly and data are interpreted correctly, Level I techniques can provide an indication of contamination.
II	Field analyses using more sophisticated portable analytical procedures, such as gas chromography for organics and atomic absorption or x-ray fluorescence for metals. The instruments may be set up in a mobile on-site laboratory. Results are available in real time or within several hours, and may provide tentative identification of compounds or be analyte specific. Data are typically reported in concentration ranges, and detection limits may vary from low parts per million to low parts per billion. Data quality depends on the use of suitable calibration standards, reference materials, sample-handling procedures, and training of the operator. In general, Level II techniques and instruments are mostly limited to organics, metals, and radionuclide screening methods.
III	All analyses performed at an off-site analytical laboratory. Level III analyses may or may not use contract laboratory program procedures, but do not usually use the validation or documentation procedures required of contract laboratory program Level IV analysis. Detection limits and data quality are similar to Level IV, but results will generally be available in a shorter time.
IV	The contract laboratory program routine analytical services. All analyses are performed in an off-site contract laboratory program analytical laboratory following contract laboratory program protocols. Generally, low part-per-billion detection limit for substances on the Target Compound List, but may also provide identification of non-Target Compound List compounds. Samples results may take several days to several weeks, and additional time may be required for data validation. Level IV results have known data quality supported by rigorous quality assurance and quality control protocols and documentation.
V	Analysis by nonstandard methods. All analyses are performed in an off-site analytical laboratory that may or may not be a contract laboratory program laboratory. Method development or method modification may be required for specific constituents or detection limits, and additional lead time may be required. Detection limits and data quality are method specific. The contract laboratory program special analytical services are Level V.

- Terrestrial wildlife or domestic livestock coming near or on WAG 1 and coming into direct contact with or inhaling contaminants from the site in the soil, ingesting contaminated plant food, ingesting contaminated water and sediments, or being exposed to direct radiation

- Surface runoff of contamination from WAG 1 to Raccoon Creek and the Northwest Tributary with resulting exposure of aquatic organisms through ingestion or direct radiation

- Migration of contaminants from the site through groundwater discharging into Raccoon Creek, the Northwest Tributary, and other potential off-WAG 1 discharge points, resulting in exposure of aquatic organisms by direct radiation or ingestion

The baseline environmental assessment will be performed ORNL-wide (i.e., including all WAGs) and will not be performed individually as part of the WAG 1 RI. Existing ORNL studies and programs will be used as input to the ORNL-wide study.

4.3 PRELIMINARY IDENTIFICATION OF GENERAL RESPONSE ACTIONS AND REMEDIAL TECHNOLOGIES

A primary objective of the RI is to collect sufficient data so that, during the AA, a range of technically feasible remedial alternatives can be developed and evaluated for those areas within WAG 1 that may require remediation. The AA process for developing remedial alternatives generally involves the following three steps:

- Identifying applicable general remedial response actions (e.g., containment) for areas requiring remediation, as determined by the public health and environmental analysis
- Identifying and screening remedial technologies (.e.g, vertical barriers) and associated process options (e.g., slurry wall, sheet piling) for each general response action
- Combining technologies into a range of site remedial alternatives for subsequent screening and detailed evaluation

During the RI only the first two steps will be performed. In the following paragraphs, general response action and associated remedial technologies are identified for all the human exposure pathways shown in Table 4-5. Data needs for all the remedial technologies expected to be evaluated during the AA are listed in Table 4-6.

4.3.1 Identification of General Response Actions and Remedial Technologies

For the purposes of identifying a scope of work for the RI, it is assumed that all the human exposure pathways identified in Table 4-2 actually exist. In Table 4-5 a preliminary list of general response actions and associated remedial technologies is identified for each component of each pathway.

Few of the technologies identified would be sufficient to completely remediate a SWMU. It is generally expected that a combination of remedial technologies would provide the most effective solution.

LEGEND

● POTENTIALLY APPLICABLE REMEDIAL TECHNOLOGIES

			GENERAL RESPONSE ACTIONS																				
			IN-PLACE CONTAINMENT					REMOVAL						TREATMENT									T…
		REMEDIAL TECHNOLOGIES	CAPPING	VERTICAL BARRIERS	SUBSURFACE HORIZONTAL BARRIERS	SURFACE WATER/EROSION CONTROLS	SEDIMENT CONTROL BARRIERS	DECONTAMINATION	LIQUIDS REMOVAL	SLUDGE REMOVAL	SOLIDS REMOVAL	GROUNDWATER COLLECTION	GAS COLLECTION	DEWATERING	SOLIDS VOLUME REDUCTION	LIQUIDS VOLUME REDUCTION	STABILIZATION	SOLIDIFICATION	PHYSICAL TREATMENT	CHEMICAL TREATMENT	BIOLOGICAL TREATMENT	THERMAL TREATMENT (e.g. VITRIFICATION)	[cut off]
PATHWAY: SURFACE WATER	SOURCE	SWMUs/SURPLUS FACILITIES	●	●	●			●	●	●	●	●		●	●	●	●	●	●	●	●	●	●
		CONTAMINATED SOIL	●	●	●			●			●	●			●	●	●		●	●	●	●	●
	RELEASE MECHANISM	CONTAMINATED SOIL CONTACT	●			●																	
		OUTFALL DISCHARGES																					
		GW DISCHARGE TO SW																					
	TRANSPORT MEDIUM	SURFACE WATER				●			●							●		●	●	●	●	●	●
	EXPOSURE ROUTE	INGESTION																					
		DERMAL CONTACT																					
		DIRECT RADIATION																					
	RECEPTORS	RESIDENT ON-ORNL																					
		RESIDENT OFF-ORNL																					
		INTRUDER																					
PATHWAY: GROUND-WATER	SOURCE	SWMUs/SURPLUS FACILITIES	●	●	●			●	●	●	●	●		●	●	●	●	●	●	●	●	●	●
		CONTAMINATED SOIL	●	●	●			●			●	●			●	●	●	●	●	●	●	●	●
	RELEASE MECHANISM	LEAKS IN TANKS/PIPES																					
		CONTAMINATED SOIL CONTACT	●	●																			
		GW INFILTRATION	●			●																	
	TRANSPORT MEDIUM	GROUNDWATER	●	●	●							●				●			●	●			●
	EXPOSURE ROUTE	INGESTION																					
		DERMAL CONTACT																					
		DIRECT RADIATION																					
	RECEPTORS	RESIDENT ON-ORNL																					
		RESIDENT OFF-ORNL																					
		INTRUDER																					
PATHWAY: BIOTA	SOURCE	SWMUs/SURPLUS FACILITIES	●	●	●			●	●	●	●	●		●	●	●	●	●	●	●	●	●	●
		CONTAMINATED SOIL	●	●	●			●			●	●			●	●	●	●	●	●	●	●	●
	RELEASE MECHANISM	TERR. FLORA/FAUNA UPTAKE																					
		AQUATIC FLORA/FAUNA UPTAKE																					
	TRANSPORT MEDIUM	FOOD CHAIN																					
	EXPOSURE ROUTE	INGEST AQUATIC ORGANISMS																					
		INGEST TERR. FLORA (CROPS)																					
		INGEST TERR. FAUNA																					
		INGEST BY-PRODUCTS (MILK)																					
	RECEPTORS	RESIDENT ON-ORNL																					
		RESIDENTOFF-ORNL																					
		INTRUDER																					

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ANSP.		STOR-AGE		DIS-POSAL		OTHER OPTIONS /TECHNOLOGIES			
	CONTAINERIZED	BULK	CONTAINERIZED	ON-SITE	OFF-SITE	INSTITUTIONAL CONTROLS	OPERATIONAL CONTROLS	REPAIR FACILITY	REMOVE FACILITY FROM OPERATION
●	●	●	●	●	●			●	●
●	●	●	●	●	●				
●	●	●	●	●	●				
						●			
						●			
						●			
						●			
						●			
						●			
	●	●	●	●	●				
	●	●	●	●	●				
	●	●	●	●	●				
	●	●	●	●	●				
	●	●	●	●	●				
						●			
						●			
						●			
						●			
						●			
						●			
						●			

TABLE 4-5
PRELIMINARY IDENTIFICATION
OF REMEDIAL TECHNOLOGIES
BY PATHWAYS

LEGEND

● POTENTIALLY APPLICABLE REMEDIAL TECHNOLOGIES

			GENERAL RESPONSE ACTIONS																			
			IN-PLACE CONTAINMENT					REMOVAL						TREATMENT								
		REMEDIAL TECHNOLOGIES	CAPPING	VERTICAL BARRIERS	SUBSURFACE HORIZONTAL BARRIERS	SURFACE WATER/ EROSION CONTROLS	SEDIMENT CONTROL BARRIERS	DECONTAMINATION	LIQUIDS REMOVAL	SLUDGE REMOVAL	SOLIDS REMOVAL	GROUNDWATER COLLECTION	GAS COLLECTION	DEWATERING	SOLIDS VOLUME REDUCTION	LIQUIDS VOLUME REDUCTION	STABILIZATION	SOLIDIFICATION	PHYSICAL TREATMENT	THERMAL TREATMENT (e.g. VITRIFICATION)	CHEMICAL TREATMENT	BIOLOGICAL TREATMENT
PATHWAY: SOIL	SOURCE	SWMUs/SURPLUS FACILITIES	●	●	●			●	●	●	●	●		●	●	●	●	●	●	●	●	●
		CONTAMINATED SOIL	●	●	●			●				●			●	●	●	●	●	●	●	●
	RELEASE MECHANISM	SURFACE LEAKS																				
		SURFACE SPILLS/ OVERFLOWS																				
		FALLOUT																				
		SURFACE RUNOFF				●													●	●	●	
	TRANSPORT MEDIUM	IN-PLACE SOIL	●								●				●		●		●		●	●
	EXPOSURE ROUTE	DERMAL CONTACT																				
		INGESTION																				
		DIRECT RADIATION																				
	RECEPTORS	RESIDENT ON-ORNL																				
		RESIDENT OFF-ORNL																				
		INTRUDER																				
PATHWAY: AIR	SOURCE	SWMUs/SURPLUS FACILITIES	●	●	●			●	●	●	●	●		●	●	●	●	●	●	●		●
		CONTAMINATED SOIL	●	●	●			●				●			●	●	●	●	●	●	●	●
	RELEASE MECHANISM	WIND EROSION	●														●					
		ON-SITE ACTIVITY																				
		VOLATILIZATION	●																			
	TRANSPORT MEDIUM	AIR																				
	EXPOSURE ROUTE	INHALATION																				
		DIRECT CONTACT																				
		DIRECT RADIATION																				
	RECEPTORS	RESIDENT ON-ORNL																				
		RESIDENT OFF-ORNL																				
		INTRUDER																				
PATHWAY: SEDIMENTS	SOURCE	SWMUs/SURPLUS FACILITIES	●	●	●			●	●	●	●	●		●	●	●	●	●	●	●	●	●
		CONTAMINATED SOIL	●	●	●			●				●			●	●	●	●	●	●	●	●
	RELEASE MECHANISM	PRECIP. CAUSED EROSION	●			●	●															
		FLOODING ON-SITE ACTIVITIES	●			●	●															
	TRANSPORT MEDIUM	SEDIMENTS	●				●				●			●	●		●		●		●	●
	EXPOSURE ROUTE	INCIDENTAL INGESTION																				
		DERMAL CONTACT																				
		DIRECT RADIATION																				
	RECEPTORS	RESIDENT ON-ORNL																				
		RESIDENT OFF-ORNL																				
		INTRUDER																				

TRANSP.		STORAGE		DISPOSAL		OTHER OPTIONS /TECHNOLOGIES			
BULK	CONTAINERIZED	BULK	CONTAINERIZED	ON-SITE	OFF-SITE	INSTITUTIONAL CONTROLS	OPERATIONAL CONTROLS	REPAIR FACILITY	REMOVE FACILITY FROM OPERATION
●	●	●	●	●	●			●	●
●	●	●	●	●	●				
								●	●
							●		
							●		
●	●	●	●	●	●				
						●			
						●			
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						●			
						●			
						●			
●	●	●	●	●	●			●	●
●	●	●	●	●	●				
				●	●				
						●			
						●			
						●			
						●			
						●			
						●			
	●	●	●	●	●			●	●
	●	●	●	●	●				
							●		
	●	●	●	●	●				
						●			
						●			
						●			
						●			
						●			
						●			

TABLE 4-5 (Cont'd)

PRELIMINARY IDENTIFICATION OF REMEDIAL TECHNOLOGIES BY PATHWAYS

LEGEND:

● FIELD SAMPLING PLAN DATA REQUIRED

DATA NEEDS

GENERAL RESPONSE ACTIONS	REMEDIAL TECHNOLOGIES	CONTAINMENT CHARACTERIZATION					PHYSICAL C																		
		RADIO-LOGICAL			CHEM-ICAL		SOIL								ROCK		SURFACE-WATER						GROUNDW		
		ACTIVITY TYPES	ISOTOPES	VERTICAL & AREAL CONCENTRATION	CONTAMINANT TYPES	VERTICAL AND AREAL CONCENTRATIONS	TYPE	MOISTURE CONTENT	POROSITY	GRAIN SIZE	SPECIFIC GRAVITY	PERMEABILITY	LEACHABILITY	RETARDATION CHARACTERISTIC	TYPE	PERMEABILITY	LEVELS	DRAINAGE PATTERNS	FLOW RATES	INFILTRATION	EVAPOTRANS-PIRATION	PRECIPITATION	LEVELS	FLOW DIRECTIONS	
IN-PLACE CONTAINMENT	CAPPING	●	●	●	●	●	●											●	●						
	VERTICAL BARRIERS	●	●	●	●	●	●	●		●	●	●			●	●		●					●	●	
	SUBSURFACE HORIZ. BARRIERS	●	●	●	●	●																			
	SURFACE/EROSION CONTROLS	●	●	●	●	●											●	●	●	●					
	SEDIMENT CONTROL BARRIERS	●	●	●	●	●																			
REMOVAL	DECONTAMINATION	●	●	●	●	●																			
	LIQUIDS REMOVAL	●	●	●	●	●																			
	SLUDGE REMOVAL	●	●	●	●	●																			
	SOLIDS REMOVAL	●	●	●	●	●	●				●														
	GROUNDWATER COLLECTION	●	●	●	●	●	●					●											●	●	●
	GAS COLLECTION	●	●	●	●	●	●																		
TREATMENT	DEWATERING	●	●	●	●	●																			
	SOLIDS VOLUME REDUCTION	●	●	●	●	●																			
	LIQUIDS VOLUME REDUCTION	●	●	●	●	●																			
	SOLIDIFICATION	●	●	●	●	●	●	●		●													●	●	●
	PHYSICAL TREATMENT	●	●	●	●	●	●																		
	CHEMICAL TREATMENT	●	●	●	●	●																			
	BIOLOGICAL	●	●	●	●	●																			
	THERMAL	●	●	●	●	●																			
TRANSPORTATION	BULK	●	●	●	●	●		●		●															
	CONTAINERIZED	●	●	●	●	●		●		●															
STORAGE	BULK	●	●	●	●	●		●		●															
	CONTAINERIZED	●	●	●	●	●		●		●															
DISPOSAL	ON-SITE	●	●	●	●	●		●		●		●	●												
	OFF-SITE	●	●	●	●	●		●		●		●	●												
OTHER OPTIONS	INSTITUTIONAL CONTROLS	●	●	●	●	●																			
	OPERATIONAL CONTROLS	●	●	●	●	●																			
	REPAIR FACILITY																								
	REMOVE FACILITY FROM OPERATION																								

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...ACTERIZATION

...ER	SEDIMENTS			WASTE		AIR				BIOTA							HUMAN POPULATION			FACILITIES		
DISCHARGE TO SURFACE WATER	TYPE	EROSION RATE	TRANSPORT AND DISPOSITION	TYPE	LEACHABILITY	TOTAL SUSPENDED PARTICULATES	PREVAILING WIND DIRECTION	WIND SPEEDS	RESUSPENSION	FLORA AFFECTED	AREAL DISTRIBUTION	UPTAKE	FAUNA AFFECTED	AREAL DISTRIBUTION	UPTAKE	SIGNIFICANT FOOD CHAINS	AGES-NUMBERS	CONSUMPTION PATTERNS	ACTIVITIES	CONFIGURATION	CONDITION	OPERATIONS
				●																●	●	●
																				●	●	●
																				●	●	●
																				●	●	●
																				●		
				●																		
				●																		
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				●																●	●	●
																				●	●	●
																				●	●	●

TABLE 4-6
TYPES OF DATA REQUIRED
TO SUPPORT
REMEDIAL ALTERNATIVES
DEVELOPMENT

4.3.2 Identification of Data Needs

The data needs identified for the first phase of the RI to support the AA development of alternatives are summarized in Table 4-6. Additional data needs may be identified as a result of the first iteration of the RI.

5.0 TECHNICAL APPROACH TO THE REMEDIAL INVESTIGATION, ANALYSES, AND REPORTING

The objectives of the WAG RI are to gather and analyze the data necessary to perform a baseline assessment of risk to human health and environment, and to develop and assess remedial alternatives. Section 3.0 described the status of the existing knowledge relating to the nature and extent of WAG 1 contamination, based on the data collected by ORNL and other agencies. Section 4.0 identified data needs necessary to perform a baseline risk assessment and to assess remedial technologies applicable to WAG 1.

Existing data are not sufficient to fulfill the objectives of the WAG 1 RI. This section describes the technical approach used for collecting and analyzing the data necessary to fulfill these objectives. It also describes the format in which the results of this RI will be reported.

5.1 DATA ACQUISITION

5.1.1 Sampling Plan

All SWMUs were identified in the ORNL RFA on the basis of existing data indicating radiological and/or heavy metal contamination. The sequencing of sample collection considered here is designed to: 1) utilize effective field screening techniques for these contaminants, as well as for volatile organic compounds for site characterization, and 2) specify locations in need of more extensive sampling and analysis to support the baseline assessment. The field sampling to support the baseline assessment is contingent upon results from the initial field screening for site characterization. This effort should reduce cost and focus on establishing a system that prioritizes sites for eventual remediation. In cases where past data indicate significant contamination but field screening fails to substantiate the presence of materials, some samples will be collected to verify the screening results. In all instances, approximately 1/20 of the samples having negative screening result samples will be submitted for full laboratory analysis.

The intent of this plan is to sample the environmental media (surface water, sediment, soil and groundwater) and establish how the various media interact in a setting substantially modified by human influences. Existing wells, piezometers, sumps, and dry wells will be investigated in an attempt to determine how pipeline trenches influence movement of contaminants from the source to discharge to the surface and eventually to a receptor.

The proposed sequence of events will permit initial utilization of existing facilities and relatively simple, non-invasive technologies to focus the subsequent activities (Figure 5-1). A radiation walkover survey will be conducted using the USRADS system to identify areas of surface radioactivity. This survey will be accompanied by vertical gamma logging of selected areas, particularly in SWSAs 1 and 2. Concurrent with the walkover survey, locations of sumps in building basements and dry wells adjacent to tanks will be determined to assess induced flow through water pumping (sump pumps) and presence of contamination from leaking tanks. It may become necessary to utilize some tracer tests to determine the integrity of both tanks and lines. If this is the case, then objectives and methods will be developed as separate tasks and amended to the RI Plan. As discussed in Section 3.3.1.4, pipeline trenches may have a considerable influence on groundwater flow in WAG 1. Therefore, the location of the pipeline trenches in conjunction with their proximity to creeks will be reviewed to assess these as preferential pathways for contaminant discharge from groundwater to surface water.

The second set of activities will focus on the acquisition of data to help determine the need for a more complete sampling

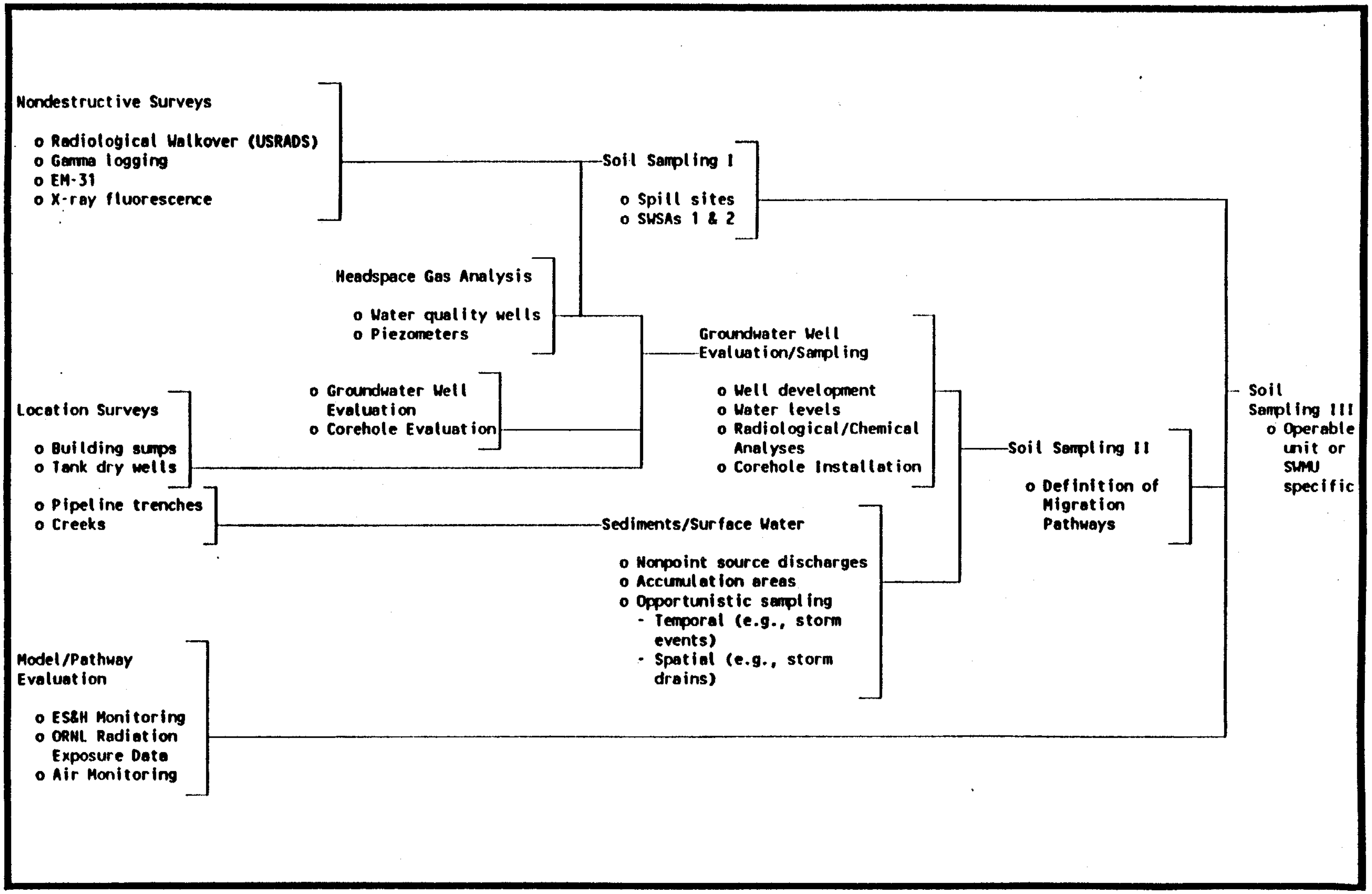

FIGURE 5-1
TECHNICAL APPROACH FOR THE SEQUENCE OF COLLECTION OF ENVIRONMENTAL SAMPLES FOR THE WAG 1 RI

effort, such as the installation of additional water quality wells. Headspace gas samples will be collected from the RCRA water quality wells and from existing piezometers to help identify the presence of volatile organic contaminants in the water table aquifer. Headspace gas analyses and evaluation of existing water chemistry data collected from WAG 1 RCRA wells will be used in conjunction with well evaluation data and water level data to determine which piezometers should be developed for subsequent sampling.

During this second set of activities, soil samples will be collected from areas of known spills, leaks, or presence of contamination to assess the nature and extent of contamination. Sediments will be collected from accumulation areas in creeks to assess the presence of non-point source discharges (i.e., seeps or groundwater discharge directly to the creeks). Areas adjacent to known contaminated sites will be sampled as appropriate. It is assumed that soil samples will be collected around the waste storage tanks. However, this cannot be stated definitively until the results of the first set of field activities are evaluated in combination with the results of the tank sampling recently completed by ORNL. Opportunistic sampling will be conducted as appropriate to look for event-specific discharge from potentially contaminated areas (i.e., SWSA 2 drainage).

The third set of activities will include the sampling of RCRA groundwater quality monitoring wells for TCL and radiological constituents and selected piezometers for gross rad, ICP metals, and organics if indicated by screening (headspace gas analysis). If initial well evaluation and screening indicates the need for additional sampling sites, added wells may be installed and sampled.

Additional soil sampling will be undertaken following sediment/ surface water and groundwater sampling to: 1) assess the potential for tracking of the contaminant migration pathway through pipe trenches from discharge to source, and 2) aid in the evaluation of operable units or specific SWMUs.

Additional groundwater activities will be undertaken to provide a third dimension to the distribution of aquifer properties and to assess the potential for contaminant migration to depth beneath the overburden-bedrock interface. This will be attempted using existing coreholes. If data prove beneficial, confirmational transects will be installed and instrumented across other portions of WAG 1.

Background Sampling Rationale

Various documents, including the RCRA Groundwater Monitoring Technical Enforcement guidance document (EPA, 1986d) and the RCRA Facility Investigation Guidance (EPA, 1987a), and U.S. Department of Energy (DOE) Order 5400.xy recognize and address the necessity of establishing natural levels (background values) and/or ranges for specific chemical and radiological constituents to assess the presence and distribution of contamination associated with a particular site. There is no complete background data base for the ORNL environment for chemical or radionuclides.

To establish the presence and distribution of chemical and radiological contaminants in the environment attributable to an individual site, establishment of the presence and distribution of those constituents in the natural environment (baseline conditions or background) is necessary (Section A7.0, FSP). Because various rock types and their weathering products naturally contain certain levels of these constituents, determination of the natural presence and variability of specific constituents is essential. Of particular interest in natural systems are heavy metals, naturally occurring radionuclides, and possibly some organics. Because groundwater, surface water/sediments, soil, and rock all interact, determination of the variation in background concentrations for each environmental medium and how the various media interact is also necessary.

Surface water and sediment samples will be collected upstream from WAG 1 to determine the chemistry of the media entering the WAG via creeks. Groundwater will be collected from a well (wells) upgradient of WAG 1 to determine the chemistry of groundwaters associated with the water-bearing units of the Chickamauga. Soils developed on the individual units of the Chickamauga will be sampled to provide chemical and radiological constituent composition. Sample locations will be selected to minimize the effect of ORNL released contaminants transported via air or other pathways.

Background groundwater samples will be collected over time to show seasonal variations. Samples representative of overburden and bedrock waters or various hydrostratigraphic units will be sampled to assess natural variations.

5.1.2 Bench and Pilot Studies

To evaluate remedial action alternatives, bench and pilot studies may be necessary. The exact studies that may be conducted have not been determined. An assessment of data collected during the RI will lead to the identification of specific studies during preparation of the RI Report. Potential studies include treatability tests such as groundwater treatment, solidification studies for impoundment and tank sludges and sediments, and studies on in-tank solidification of sludges.

5.1.3 Related Activities

5.1.3.1 ES&H Monitoring. ES&H personnel will routinely monitor air quality around drilling and other excavation sites. These monitoring data will provide information that could be used for air pathway analyses and for soil characterization. These data will include total suspended particulate concentrations, some contaminant concentrations, and volatile organics concentrations during drilling or other excavation activities.

5.1.3.2 Source Testing by Energy Systems. The data concerning the nature and volume of contaminants contained within inactive tanks are needed to perform a risk assessment and to evaluate remedial alternatives for each inactive tank. The sampling necessary to characterize the nature, concentration, and volume of contaminants in each inactive tank will be performed by Energy Systems in accordance with protocols established by ORNL and reviewed by BNI.

5.1.4 Definition of ARARs

Existing ARARs will be used to the maximum extent possible to define the allowable levels of contaminants of concern that are present in each media (e.g., air, surface water, soils, groundwater) at the site. Where ARARs for contaminants of concern have not been established, allowable concentrations will be developed. For radioactive parameters, a model developed by Gilbert et al. (1985) will be used. For chemical parameters, research of published literature on toxicology, carcinogenicity, and physical properties will be conducted to establish acceptable concentrations.

5.2 DATA ANALYSIS

During and near the conclusion of the Phase 1 RI work, the data collected from the RI activities and from other monitoring networks will be reduced, verified, and validated. The data will then be analyzed to characterize the site. The data will be reviewed to see if chemical and radiological contamination occur concurrently. Statistical, graphic, or cartographic methods will be used for inference purposes. Data will be evaluated for surface runoff and groundwater modeling.

If found adequate, input matrices for the respective models will be prepared, and the models will be simulated. Modeling will help characterize the site further and will help in identifying the worst-case contributors to risk.

Following site characterization, the adequacy of data for risk assessment will be evaluated. If found to be inadequate, new data needs will be identified in an interim report. A new sampling plan will be identified, and another RI iteration will be recommended.

If the data are found to be adequate, a risk assessment will be performed. Following the risk assessment, the potential SWMUs and sources within the WAG will be selected for remedial alternative evaluations. Data adequacy for the remedial alternatives assessment will also be evaluated. Again, if found inadequate, a new sampling plan will be identified and prepared. At the conclusion, a final RI Report will be presented.

5.2.1 Modeling

It is anticipated that detailed mathematical models may be useful in describing contaminant transport and performing risk analyses. After an initial assessment of the RI data, specific analytical models will be reviewed to determine their applicability and value to the project. Suitable models will be used to perform analysis. A comprehensive list of models is presented in the RI/FS project Data Base Management Plan (BNI, 1987d).

For flow, contaminant transport, and risk analyses, the following models have been identified for possible use on WAG 1:

- Groundwater flow and transport -- SWIFT
- Overland flow and transport -- CREAMS
- Geochemistry -- PHREEQE

o Risk analysis -- Model prepared by Gilbert et al., (1985)
-- AIRDOS, RADRISK

5.2.2 Statistical Analysis

Raw data will be analyzed with available statistical techniques to derive useful correlations, trends, averages, etc. These methods will also be used to prioritize selected sampling sites, to revise analytical procedures, and to identify archived samples for analyses relative to vertical distribution of contaminants.

5.3 GENERIC STUDIES

Generic studies may be performed as a cost-effective approach for addressing techniques or issues that apply to more than one WAG or that are needed to complete the Feasibility Study. Such studies may include an ecological investigation, a sediment transport study for WOC basin, waste and water treatment studies, containment design studies, migration analysis studies, off-site disposal studies, and regulatory strategy studies.

5.4 RI REPORTS

During and at the end of each phase of the RI work, the data collected will be analyzed and presented. Raw data will be analyzed using techniques presented in Section 5.2. Data summaries will be prepared in tabular, graphic, or cartographic form. The final RI Report format is presented in Table 5-1.

The RI report will consolidate all available, appropriate, and applicable data on WAG 1. The report will contain or reference all data that will impact the evaluation and selection of remedies for SWMUs within WAG 1. The report will have the following objectives:

- To summarize the analysis conducted by the project team, and to the extent possible, define the areal and vertical extent of contamination

- To present the team's assessment of surface and subsurface conditions impacting contaminant migration

- To provide a risk assessment for each SWMU or collection of SWMUs

- To present a summary of potentially feasible remedial actions

The RI Report will also include a preliminary identification of ARARs from federal and state statutes. Early identification of ARARs (and signoff by review agencies) will clarify issues to be addressed in the AA phase of the RI/FS project.

The body of the report will present a concise summary of the technical work completed on the project. The report will be written in language easily understood by the public. To reduce the complexity of the report, materials will be presented, to the extent possible, with a high reliance on figures and tables, with text minimized. Complex computations and analyses will be placed in appendices.

TABLE 5-1

PRELIMINARY REMEDIAL INVESTIGATION REPORT FORMAT

Executive Summary

1. Introduction
    - 1.1 Purpose of Report
    - 1.2 Site Background
        - 1.2.1 Site Description
        - 1.2.2 Site History
        - 1.2.3 Previous Investigations
    - 1.3 Report Organization

2. Study Area Investigation
    - 2.1 Includes field activities associated with site characterization. These may include physical and chemical monitoring of some, but not necessarily all, of the following:
        - 2.1.1 Surface Features (topographic mapping, etc.) (natural and manmade features)
        - 2.1.2 Contaminant Source Investigations
        - 2.1.3 Meteorological Investigations
        - 2.1.4 Surface Water and Sediment Investigations
        - 2.1.5 Geologic Investigations
        - 2.1.6 Soil and Vadose Zone Investigations
        - 2.1.7 Groundwater Investigations
    - 2.2 If technical memoranda documenting field activities were prepared, they may be included in an appendix and summarized in this report chapter.

3. Physical Characteristics of the Study Area
    - 3.1 Includes results of field activities to determine physical characteristics. These may include some, but not necessarily all, of the following:
        - 3.1.1 Surface Features/Includes topography, SWSA locations, wells, benchmarks, etc.
        - 3.1.2 Geophysical Features/Includes locations of buried trenches, SWSA locations and buried objectives in SWSAs, etc.
        - 3.1.3 Surface Water Hydrology
        - 3.1.4 Geology
        - 3.1.5 Soils
        - 3.1.6 Hydrogeology
        - 3.1.7 Demography and Land Use
        - 3.1.8 Groundwater

4. Nature and Extent of Contamination
    - 4.1 Presents the results of site, both natural chemical and radiological components and chemical and radiological contaminants in some, but not necessarily all, of the following media:

4.1.1 Sources (lagoons, sludges, tanks, leak and spill sites, etc.)
4.1.2 Rock Formations (including faults, fractures, and wells)
4.1.3 Groundwater
4.1.4 Surface Water and Sediments
4.1.5 Air

5. Contaminant Fate and Transport
   5.1 Potential Routes of Migration (i.e., air, groundwater, etc.)
   5.2 Contaminant Persistence
      5.2.1 If they are applicable (for organic and radiological contaminants), describe estimated persistence in the study area environment and physical, chemical, and/or biological factors of importance for the media of interest.
   5.3 Contaminant Migration
      5.3.1 Discuss factors affecting contaminant migration for the media of importance (e.g., sorption into soils, solubility in water, movement of groundwater, etc.)
      5.3.2 Discuss modeling methods and results, if applicable.

6. Identification of Bench and/or Pilot Scale Testing Requirements

7. Baseline Risk Assessment
   7.1 Identification of Potential ARARs
   7.2 Public Health Evaluation
      7.2.1 Exposure Assessment
      7.2.2 Toxicity Assessment
      7.2.3 Risk Characterization
   7.3 Environmental Assessment

8. Summary and Conclusions
   8.1 Summary
      8.1.1 Nature and Extent of Contamination
      8.1.2 Fate and Transport
      8.1.3 Risk Assessment
   8.2 Conclusions
      8.2.1 Identification of Potentially Feasible Alternatives for Individual SWMUs or Collection of SWMUs
      8.2.2 Data Limitations and Recommendations for Future Work
      8.2.3 Scope and Schedule for Alternatives Assessment

TABLE 5-1 (Continued)

Appendices

A. Technical Memoranda on Field Activities (if available)
B. Analytical Data and QA/AC Evaluation Results
C. Risk Assessment Methods
D. Detailed Discussion of Modeling Efforts
E. Calculations
F. Boring Logs

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APPENDIX A

FIELD SAMPLING PLAN
FOR
ORNL WASTE AREA GROUPING 1
REMEDIAL INVESTIGATION

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A1.0 INTRODUCTION

A1.1 PURPOSE

This FSP describes sample locations and the sampling procedures to be followed by the BNI RI Team during the RI of WAG 1 of the ORNL. The BNI RI Team includes all subcontractor personnel performing work on the RI for ORNL WAG 1.

The results of previous investigations, observations made during site visits, and information obtained in discussions with those familiar with the site were used in preparing this sampling plan. Data collected since the time of the initial issuance of the WAG 1 FSP (December 1987) have been discussed in the previous sections and have been incorporated into the sampling philosophy and design of this revision. Certain aspects of this plan may be modified as the field work progresses and more data become available; for example, identification of a new source of contamination may result in additional sampling in that area.

A1.2 SITE BACKGROUND

WAG 1 comprises most of the Main Plant Area of ORNL, which lies within Bethel Valley at the southwestern end of the DOE ORR. A site map is shown in Figure A1-1, and a corresponding list of SWMUs is provided in Table A1-1.

The original facilities at ORNL were constructed during the early 1940s for demonstrating production and separation of plutonium. Upon completion of the original mission, ORNL was charged with chemical engineering research responsibilities and also with research programs in the basic sciences and in nuclear reactor and isotope development. During operation of the facility, research and demonstration reactors were constructed and operated, and large quantities of isotopes were produced. Also, broad programs in metallurgical and solid state and high energy

BETHEL VALLEY ROAD
HILLTOP CIRCLE
FIRST CREEK
WEST END CIRCLE
FIRST STREET
THIRD STREET
FIFTH STREET
CENTRAL AVENUE
OAK AVENUE
WHITE OAK CREEK
NW TRIBUTARY
SWSA-2
SWSA-1
WASTE PILE
COAL YARD
NORTH
SOUTH
I
II
III
IV
V
VI
N23,000
N22,500
N22,000
N21,500
N21,000
N20,500
N20,000
E29,000
E29,500
E30,000
E30,500
E31,000
E31,500
E32,000
E32,500
E33,000
GRID NORTH
TRUE NORTH
NOTES
LEGEND
BUILDING
PAVED ROADS
GRAVEL ROADS
FENCE
STREAM
BASIN/POND
MARSHY AREA
WAG 1 BOUNDARY
SOLID WASTE MANAGEMENT UNITS
COLLECTION & STORAGE TANK
LAND DISPOSAL FACILITY
WASTE TREATMENT FACILITY
LEAK OR OIL SPILL
BASIN/POND
1.3 SWMU NUMBER
FIGURE A1-1
WAG 1 SITE MAP
A1-2
19118 E22W9802.DGN
34 X 44
139

TABLE A1-1

LISTING OF WAG 1 SWMUs

Solid Waste Management Units	Number of SWMUs
Collection and Storage Tanks (LLW)	
Inactive	25
Active	20
Leak/Spill Sites and Contaminated Soils	
Radioactive	30
Chemical	4
Ponds and Impoundments	
Radioactive Waste	6
Chemical Waste	2
Waste Treatment Facilities	
Radioactive Waste	2
Solid Waste Storage Areas	
Radioactive Waste	2
Chemical Waste	1
Total Number of WAG 1 SWMUs	92

Source: Boegly et al. (1987); Rohwer (1989).

physics research were conducted. ORNL management has performed a preliminary assessment of contamination at the ORNL facility. A list has been compiled of all known active and inactive waste management units, contaminated facilities, and other potential sources of past and continuing releases of contaminants to the environment. For remedial planning purposes, these sites have been grouped into 20 geographically contiguous and hydrologically defined WAGs. WAG 1 comprises most of the Main Plant Area at ORNL and includes 92 known SWMUs. These SWMUs have been classified into the five types listed in Table A1-1.

During preparation of the WAG 1 RI Plan, existing information pertaining to all SWMUs and to general environmental contamination within WAG 1 was evaluated. Additional data needs to perform a baseline health assessment and to develop and evaluate a range of remedial alternatives were identified. This FSP addresses the collection of additional field data to satisfy those needs.

A1.3 FSP ACTIVITIES

Based on an assessment of the operational history of the WAG 1 SWMUs and a review of pertinent site characterization studies, completion of the baseline health assessments requires: 1) source characterization including establishing the presence, absence, and concentration gradients of contaminants, 2) pathway characterization including the mechanics of source/pathway/receptor interfaces, and 3) receptor locations. Data also will be obtained to support the development of remedial alternatives.

The following activities will be performed during the first phase of field sampling:

- Civil surveys will be conducted to designate the location of specific sampling sites.
- Surface radiological surveys will be used to assist in determining soil sampling locations.

- o EM-31 will be employed in SWSAs 1 and 2 and in the Waste Pile area to aid in determining the location of trenches and waste forms. It also will be used to aid in pipeline locations in areas where sampling will be undertaken.

- o X-ray fluorescence will be used to determine the presence of heavy metal constituents in soils and sediment. This effort will be used to screen for suspected contamination in areas possibly requiring more extensive sampling.

- o Headspace gas analysis will be used in water quality and piezometer wells to determine the presence of volatile organic chemicals and to focus subsequent groundwater and subsurface soil sampling.

- o Surface and subsurface soils sampling will be conducted in areas to provide radionuclide and chemical contaminants data. These areas initially will be identified during the nondestructive survey phase.

- o Building sumps and tank drywells will be inventoried and sampled as required to provide information on possible groundwater contaminants.

- o Personnel exposure information will be obtained from existing ORNL records or from monitoring conducted during the RI effort.

- o The existing groundwater well network will be used, where possible, to define the nature, distribution, and movement of contaminants in groundwater. Additional groundwater monitoring wells will be installed, if needed, to more completely evaluate the groundwater flow systems and contaminant transport therein.

- o Surface water and sediments in the three major streams within WAG 1 will be sampled. Opportunistic samples will be collected in areas appropriate to refining information on contaminant distribution and migration.

An iterative approach will be used to collect samples needed to satisfy the RI requirements. As data on the nature and extent of contamination become available from the first phase of sampling identified in this FSP, sampling efforts should narrow to a few significant areas where more intense sampling may occur during subsequent phases.

The BNI RI Team will be responsible for collecting all samples and data specified in this FSP. A separate sampling effort has been conducted by ORNL to characterize the contents of the inactive waste storage tanks. Data from this tank sampling activity is being used for source identification and to help define contaminant migration routes. Collection of groundwater and surface water samples will coincide, as appropriate, in an effort to obtain a coherent, comparative view of site conditions.

The proposed locations for sample collection, the procedures for sample collection, and the analyses to be performed on each sample are described in the following sections. Table A1-2 is a summary of the sampling and analysis activities for the first phase of the WAG 1 RI. It is assumed that QC samples (field blanks, trip blanks, and equipment blanks) will represent approximately 10 percent of the total sample collection effort as shown in Table A1-2.

Wastes generated as a part of the RI will be disposed according to the procedures outlined in the ORNL RI/FS Waste Management Plan (BNI, 1988a). These wastes include solids (i.e., soil borings) and liquids (i.e., drilling fluids) contaminated with both radiological and chemical constituents. An estimate of these wastes is presented in Section A11.0.

A1.4 ANALYTICAL SUPPORT

Laboratory analytical support will be provided by IT Corporation through three laboratories located in the Oak Ridge/Knoxville area. The three laboratories are: 1) the Radiological Sciences Laboratory for analyzing high-level radioactive wastes, 2) the Mixed Waste Laboratory for analyzing mixed wastes, and 3) the Full Service Environmental Laboratory for analyzing chemical constituents.

TABLE A1-2

SUMMARY OF ENVIRONMENTAL SAMPLES AND ANALYSES FOR PHASE I OF THE WAG 1 RI

Environmental Media	No. of Sample Locations	Field Analysis	Radiological Analyses[a] Gross Alpha/Beta	Gamma Spect	Alpha/Beta Isotopic	Chemical Analyses TCL	Other[b]	Engineering Properties
Sediments/Streams	15	15	50	50	28	17	50	0
Impoundments	3	6	7	7	4	7	7	0
Surface Water	8	32	39	39	19	39	39	0
Groundwater	89	395	395	395	395	86	747	0
Soils	375	413	413	413	209	192	209	100

[a]All analytical numbers include 10 percent QC samples.

[b]Includes Miscellaneous Parameter (Attachment A-2) for surface water/seeps and groundwater; also for groundwater ICP metals, for soils and sediments the number is for ICP metals analysis only.

In addition, a close-support (field) laboratory (CSL) will be established by IT during the RI field work. The CSL will allow for rapid screening of samples to: 1) identify indicator parameters which will determine if additional analyses should be performed, 2) determine how samples should be processed and packaged for shipment, and 3) to determine the laboratory to which the samples should be sent. Field testing of soils will be undertaken on-site at the BNI field support laboratory. Analytical support will include providing all sample containers, preservatives, QC blanks, container labels, and forms used in chain of custody.

A2.0 NONDESTRUCTIVE SURVEYS

The initial WAG 1 RI field activities involve a series of nondestructive surveys. These include: 1) a radiation walkover survey, 2) a series of efforts involving data for establishing personnel exposures, 3) an EM-31 survey of SWSAs 1 and 2 and the waste pile area, 4) a survey for heavy metal contaminants utilizing field portable x-ray fluorescence, and 5) an inventory of building sumps and tank drywells. Civil layout surveys will be performed as necessary to support these surveys and subsequent field activities. The general objective of these surveys is to provide preliminary characterization data to guide subsequent RI sampling and to support the baseline health assessment computations and ES&H activities. The following paragraphs describe the nature of these surveys and their functions.

A2.1 CIVIL SURVEY

Civil surveys will be conducted in conjunction with the RI to provide sufficient three dimensional control for the sediment, soil, surface water, and groundwater sampling and measurement activities.

A2.1.1 Locations and Frequency

A civil survey crew will perform the following tasks to accomplish the objectives of the RI:

- o Survey and field stake locations for nondestructive surveys;
- o Survey proposed sediment, soil, surface water (including seeps), and groundwater sampling/measurement stations as required for permitting and developing as-built drawings, if appropriate, and
- o Final (post-installation) survey location, ground surface elevation, and reference point elevation for new wells.

As these surveys are performed, the locations and elevations of selected adjacent facilities will also be surveyed as part of the quality assurance check on existing data.

A2.1.2 Equipment and Procedures

Plane and vertical surveys will be of third-order accuracy and will be conducted under the supervision of a Tennessee Registered Land Surveyor. Surveying will be performed in accordance with the applicable subsections of the EPA A Compendium of Superfund Field Operations Methods, Section 14, "Land Surveying, Aerial Photography, and Mapping," (EPA, 1987e). These procedures conform with guidance provided in the EPA Region IV Engineering Support Branch SOP and QA Manual, Section 7.2, "Site Mapping," and Section 7.3, "Ground Elevation Surveys" (EPA, 1986c).

Elevations will be referenced to the National Geodetic Vertical Datum established by the National Geodetic Survey in 1929 and will be reported to the nearest 0.01 ft. The grid system for reporting coordinates of locations will be the ORNL coordinate system.

A2.2 RADIATION WALKOVER SURVEY

A2.2.1 Locations, Frequency, and Analysis

The initial RI activity used to characterize radioactive contamination will be a radiation walkover survey. This survey will consist of a surface scan and discrete measurements made at defined locations. This survey will provide a first estimate of the extent of soil surface contamination and identify relative contamination levels throughout the site. Information from this survey will be used in selecting soil sample locations. It will also be used to select locations for population exposure estimate measurements (described in Section A2.3) that will be used for portions of the baseline health assessment.

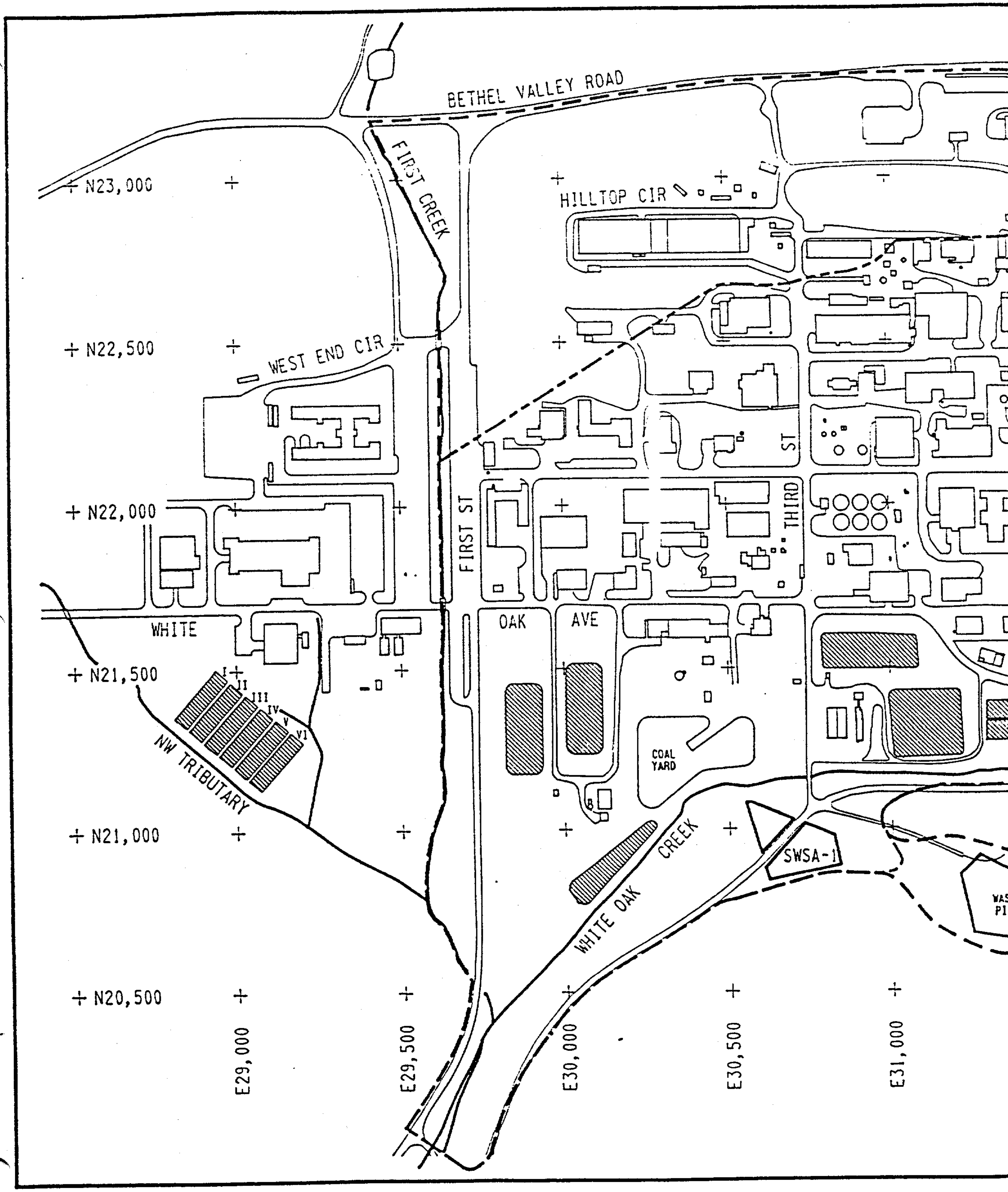
A grid will be established to facilitate locating measurement points for analysis. Grid points will be placed by civil survey at 100-ft intervals, except where obstructed by buildings or other physical features. Where the grid has to be modified due to obstructions, additional points will be added.

The walkover survey will cover the entire surface area inside the WAG boundary except for the inside of buildings, ponds, and other physically obstructed areas. The survey will be extended outside the WAG as needed to define areas of contamination which cross the WAG boundary. The maximum area of the survey shown on Figure A2-1 is arbitrary and is shown for scoping purposes only.

Background measurements will be made in uncontaminated areas, probably outside the ORR area, with the types of instruments used to perform the walkover survey. Instructions for set up and performance of the walkover survey are specified in Project Procedure 1220, "Initial Site Survey" (BNI, 1988b).

A2.2.2 Equipment and Procedures: Ultrasonic Ranging and Data Systems

USRADS are swing instruments configured with ultrasonic and electronic equipment. A swing instrument consists of a hand-held meter, ear phones, and a detector (sodium iodide) attached to the meter via a cord. The meter can alternatively read out in count rate or total count for fixed-time intervals. During gamma scanning, the gamma survey probe is moved slowly and kept as close to the surface as possible. Any significant changes in gamma radiation levels above background, indicated either by visual changes in the instrument rate meter or in the pitch of audio responses in the instrument headphones, are noted as being anomalous. The ultrasonic and electronic equipment has two functions: 1) to locate the instruments automatically with respect to a series of transponders placed at known locations at the site, and 2) to transmit the data (radiation level and



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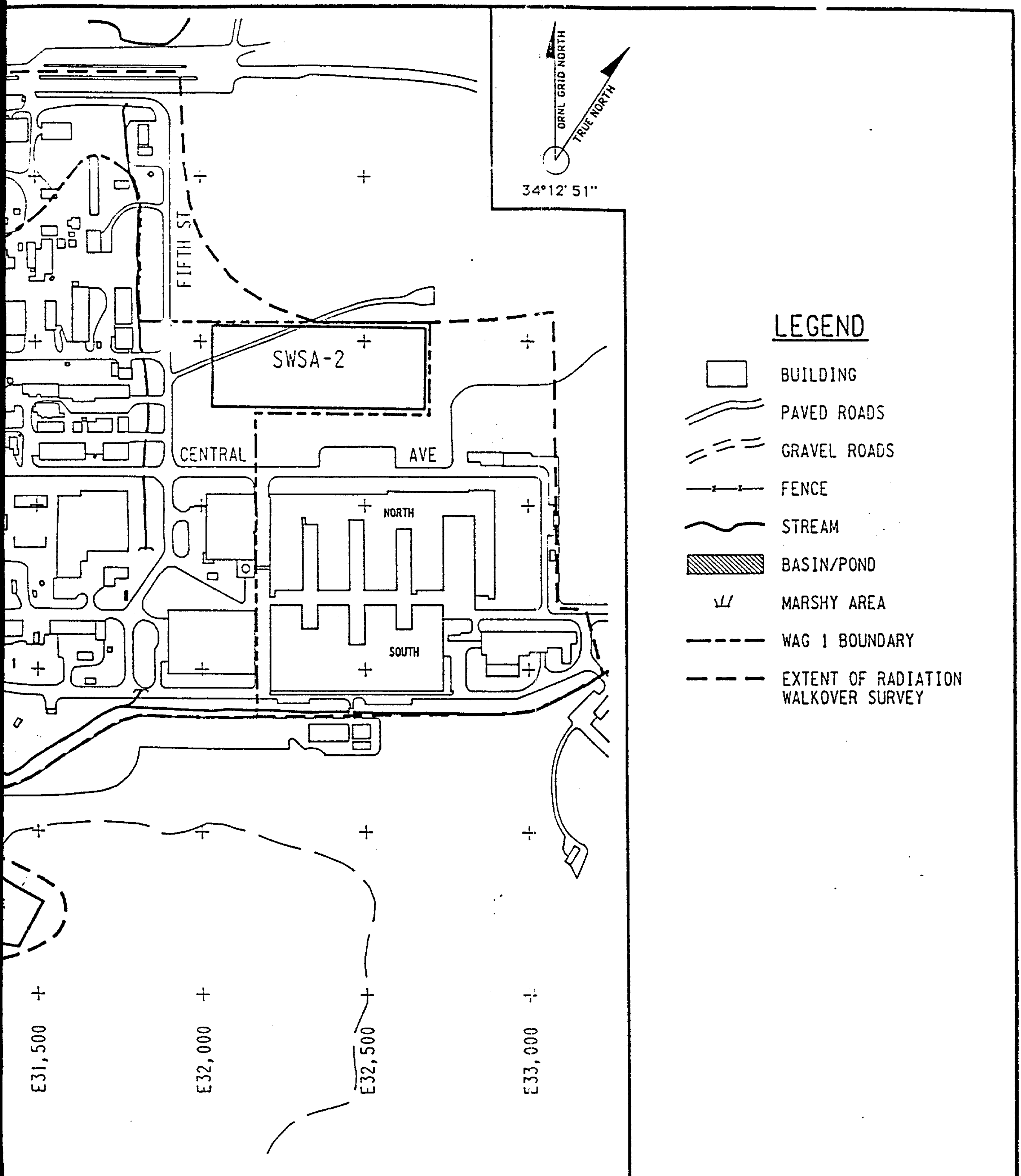


FIGURE A2-1
BOUNDARIES OF RADIATION WALKOVER SURVEY FOR WAG 1

(REV.1)

location of measurement) to a microcomputer. While the data are being collected, the microcomputer displays a map of the site and the location of each data point on the map. This lets the technicians determine if they have completely covered the site. The data are stored electronically for on-site or later analysis. The USRADS system will be operated according to procedures written in cooperation with the subcontractor.

A2.3 PERSONNEL EXPOSURE INFORMATION

The personnel exposure information includes: 1) a radiation dose rate survey, 2) information from ORNL concerning employee monitoring data, 3) Environmental, Safety and Health Monitoring, 4) existing air monitoring data, 5) organic vapor analysis, and 6) worker monitoring. The objectives of the personnel exposure information are to provide receptor locations and contaminant concentrations and dose values to be used in the baseline health assessment identified in Section 4.2.1.

A2.3.1 Population Exposure Estimate Measurements

To complete the preliminary baseline health assessment, some information is needed to determine the average penetrating radiation field along transit paths used by non-radiation workers at the ORNL site in WAG 1. Data will be combined with population transit estimates and measured transit time to estimate the population (collective) dose to non-radiation workers during operational/institutional control of the ORNL site. A combination of three methods will be used depending on initial walkover survey results. The specific method employed in any one location will be dependent upon the characteristics of the radiation fields discovered and the specific data needs. One of the following methods will be utilized:

- **Method 1: Routine Walkdown with Pressurized Ion Chamber (PIC)/Energy Compensated Geiger Muller (GM) Instruments**

  Based upon the findings of the walkover survey, potential transit paths through areas with an elevated dose rate would be identified. The dose rate along these pathways as well as the area between the hypothetical transiting individual and the source would be surveyed at intervals of 10 to 20 ft with PIC and/or compensated GM to form a field profile. These surveys would be repeated at monthly intervals for 6 to 12 months to evaluate changes and to establish the annual average field. Integration times in high dose fields (those 1 mR/h and greater) would be approximately 20 to 30 seconds for 2 percent counting statistics on the GM.

- **Method 2: Pressurized Ion Chamber (PIC) Long Term Recordings**

  Based upon the findings of the walkover survey, potential transit paths through areas with an elevated dose rate would be identified. At intervals of approximately 50 ft along each selected transit path dose measuring stations consisting of predetermined fixed survey points would be established. A series of 24-h time integrating measurements would be conducted at each station at intervals of several weeks using a recording pressurized ion chamber instrument such as the Ruter Stokes RSS-111. The average dose rate at each station would be compiled and used to estimate non-radiation worker transit dose.

- **Method 3: Tissue Equivalent TLD (TETLD) Stations**

  Based upon the findings of the walkover survey, potential transit paths through areas with an elevated dose rate would be identified. At intervals of approximately 50 ft along each selected transit path dose measuring stations consisting of multiple TETLDs in plastic shelters would be established. TLDs with fade, blind and transit controls would be exposed for 30 to 90 days over a total period of 1 yr depending on dose conditions.

A2.3.2 Employee Monitoring Data

Current employee monitoring data for radionuclides and chemicals will be used to determine the potential threat from contaminants to human health. Data will be grouped into worker categories and locations. These data will be used to supplement the data collected from the dose rate survey.

A2.3.3 Environmental, Safety and Health Monitoring

The information collected from the environmental safety and health monitoring will be used to determine the potential threat from contaminants to human health. As indicated in the ORNL RI/FS ES&H Plan (BNI, 1987), workers will be routinely monitored for exposure. Specific data will include external irradiation exposure and inhalation exposure (both radiological and organic vapor analysis).

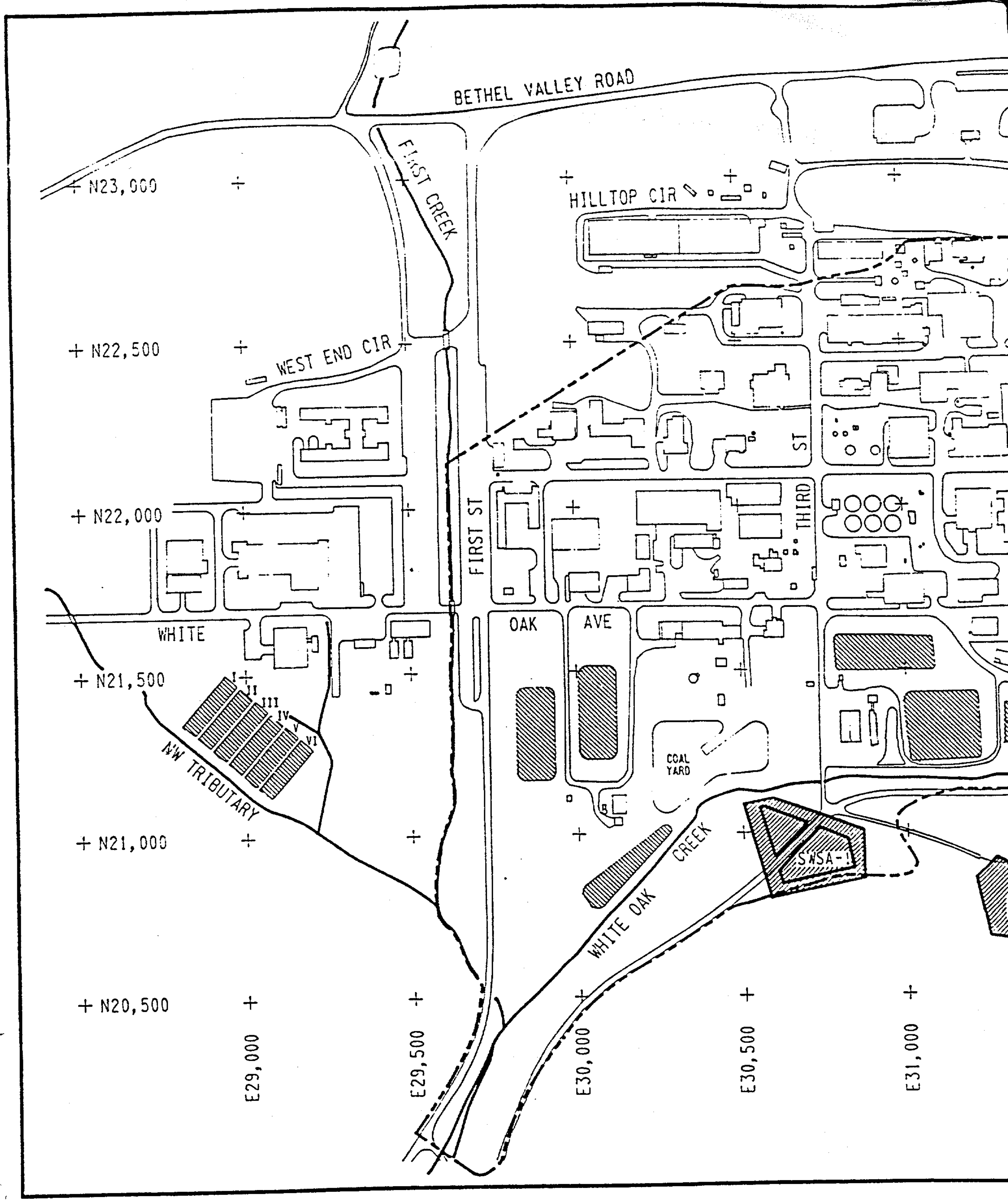
A2.3.4 Existing Air Monitoring Data

Existing radionuclide air monitoring data will be used to determine the potential threat from contaminants to human health in the inhalation pathway. The existing stations are perimeter stations and, accordingly, will be used for the off WAG receptor scenario.

A2.4 ELECTROMAGNETIC SURVEYS: SWSAs 1 AND 2 AND THE WASTE PILE AREA

Within SWSAs 1 and 2 and in the old waste pile area, the areal distribution, depth, and nature of materials buried is generally unknown. This is particularly true in SWSA 1 and the waste pile area where there are no records of disposal and/or removal. However, the original materials in SWSA 2 were, for the most part, excavated and reburied in SWSA 3 (Webster, 1976). Within the baseline health assessment, an electromagnetic (EM-31) survey will aid in delineating the areal extent of solid wastes within the three locations (Figure A2-2). The survey will be conducted after the radiation walkover survey and prior to any subsurface sampling.

The EM-3 survey will be conducted in accordance with applicable guidance from the U.S. EPA Region IV Engineering and Support Branch SOP and QA Manual, Section 7.10, "Geophysical Studies," (EPA, 1986b). Specific guidance on equipment selection and field



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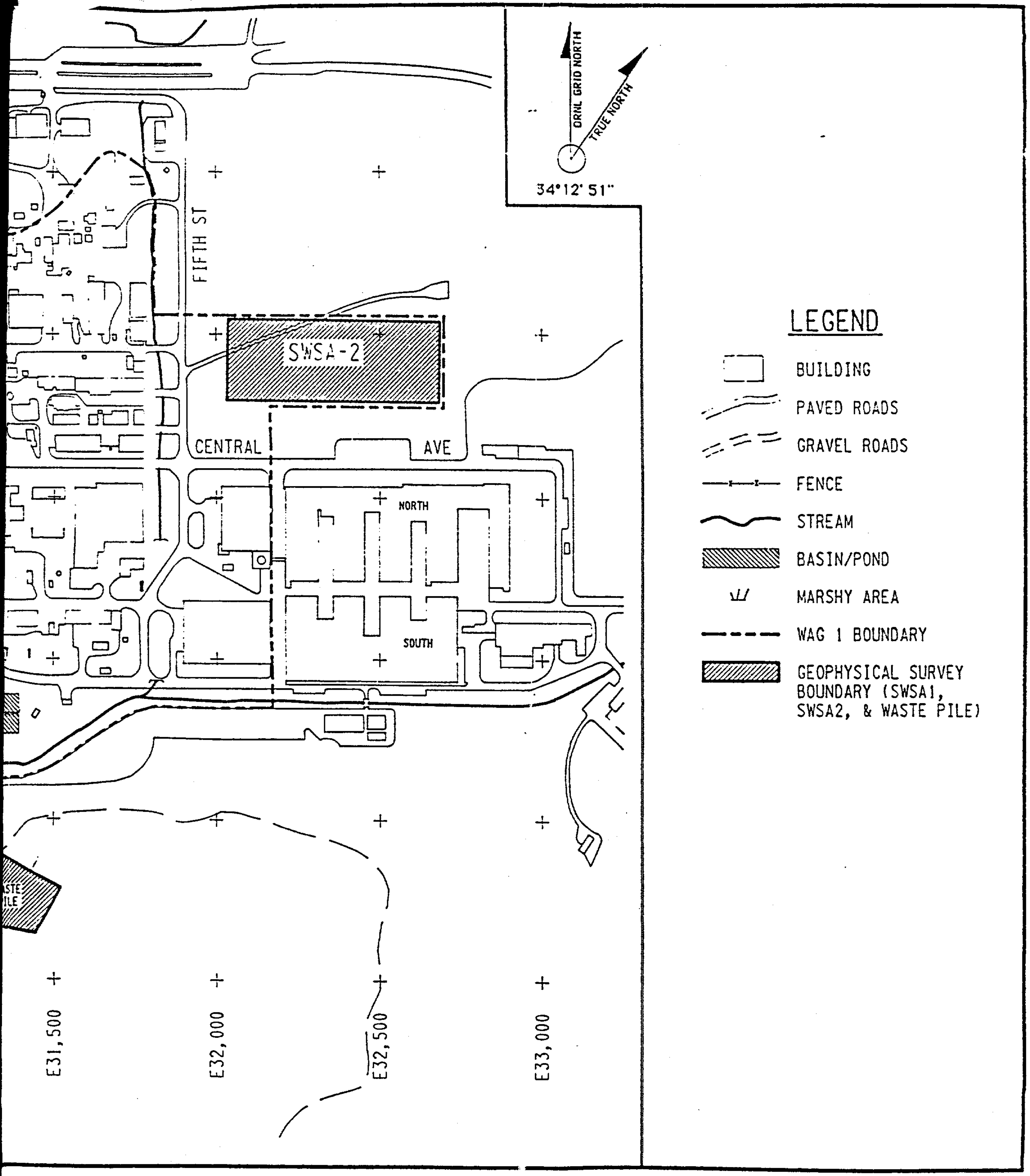


FIGURE A2-2
GEOPHYSICAL SURVEY

procedures is provided in the EPA Compendium of Superfund Field Operations Methods (EPA/540/P-87/001a and b), Section 8.4, "Geophysics" (EPA, 1987c).

The EM conductivity method is a fast and inexpensive method to acquire ground conductivity measurements. Buried trenches are often more conductive than undisturbed soils and can be located with this method. EM data will be collected in a grid pattern. Lines will be oriented north-south and will be separated by 60 ft. EM-31 data will be collected at 30-ft intervals along the lines and these data will be collected in conjunction with the USRADS system.

A2.5 X-RAY FLUORESCENCE

The use of a portable x-ray fluorescence (XRF) instrumentation analyzer connected to the USRADS system or used independently but in conjunction with the walkover survey can provide real-time analysis and display for identification of heavy metal surface contamination. This information will be used in the baseline health assessment to aid in the contaminant extent of the source. This method will be employed in those areas where it is known that metal contamination occurred or, in the case of suspected migration pathways, the source term indicated metals present in the waste.

XRF measurements are made using a field-portable XRF instrument, which utilizes a radioactive source and gas proportional tube detector to measure element specific energy emissions. Depending on the matrix being analyzed, measurements may be made in situ or on samples collected and processed to a minimal degree (i.e., sieve soil with finer fractions, 200- to 300-mesh, clay-size), giving the best analytical results. Waters and soils are placed in a cup with a thin polypropylene or mylar window stretched across the base of the water or soil column. Rocks with irregular surfaces generally give poor results.

Generally speaking, analytical results in tens-of-parts per million range can be acquired in less than a minute of counting.

A2.6 SUMPS AND DRYWELLS

Sumps within buildings and drywells associated with both the active and inactive tanks may provide a means for evaluating flow and contaminant migration throughout WAG 1 and, in particular, the area south of Central Avenue. The water table is believed to be sufficiently shallow to intersect the building basements in that area. Leakage has been noted in the drywells and some buildings. The evaluation survey for the sumps and drywells is discussed in Section A3.2.3 and sampling in A3.4.

A3.0 GROUNDWATER

A3.1 OBJECTIVES

Groundwater constitutes not only a significant pathway for migration of contaminants from WAG 1 to potential receptors but is a primary source for those receptors identified in Section 4.2.1. ORNL has conducted a preliminary investigation of groundwater flow and quality at WAG 1 and has identified that the flow regime is complex and that contaminants of various types are present in the groundwater. An investigation of WAG 1 hydrogeology will be conducted during the RI to further define groundwater flow and quality. To meet the overall baseline health assessment objectives, the RI groundwater program is designed:

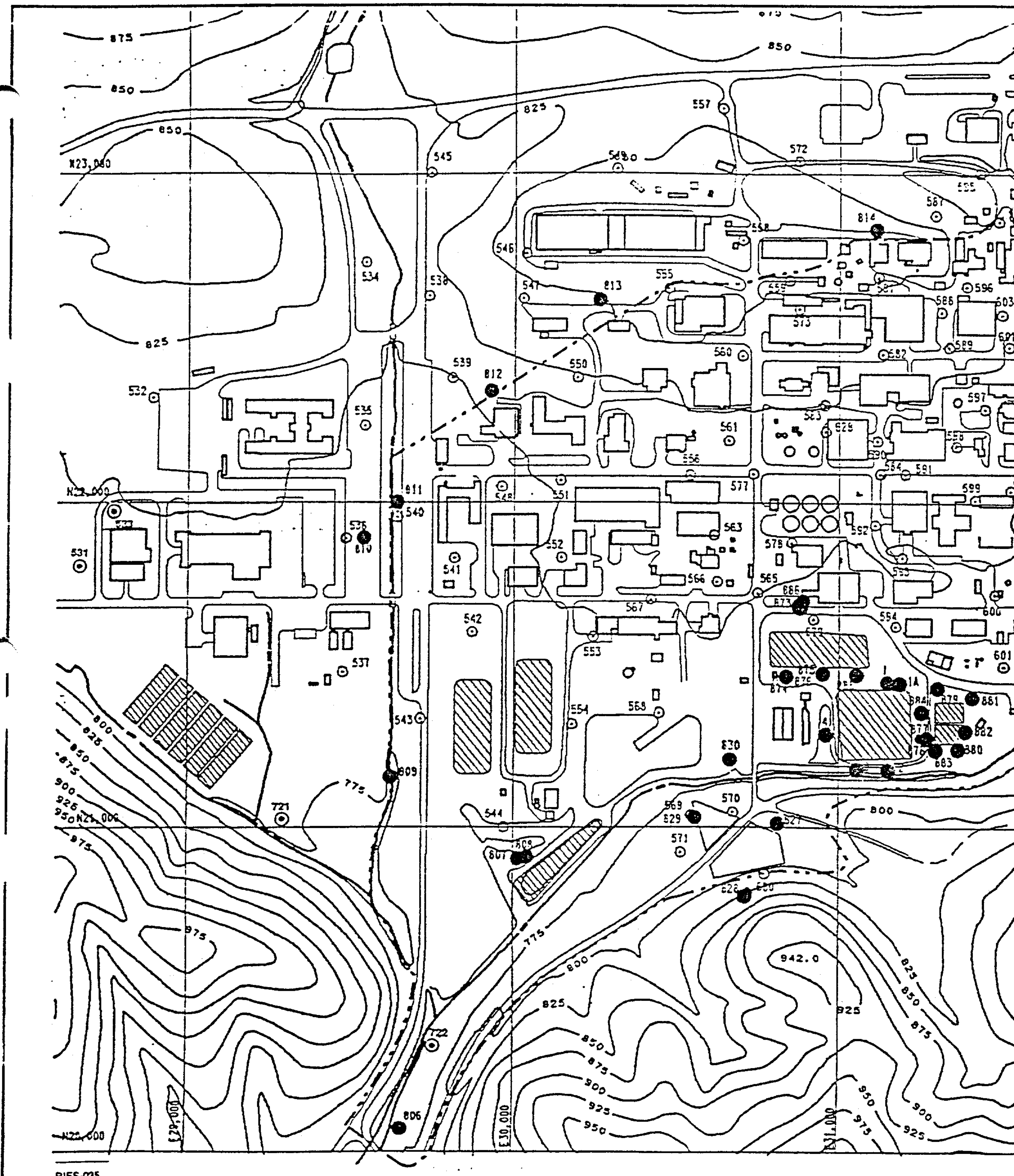
- To characterize the movement of groundwater through and away from WAG 1,
- To characterize groundwater quality in the vicinity of WAG 1, and
- To determine interaction between surface water (e.g., in creeks and impoundments) and groundwater.

To accomplish these objectives, the field activities described below will be performed.

A3.2 HEADSPACE GAS ANALYSIS

A3.2.1 Location, Number, and Tasks

Concurrent with the location and evaluation of existing wells and piezometers, headspace gas samples will be collected from up to 42 stainless steel compliance wells and up to 101 piezometers. These samples will be collected to provide qualitative field screening of the presence of volatile organic contaminants in the transport medium (water) present in the subject wells. Locations to be sampled are shown on Figure A3-1. A preliminary field



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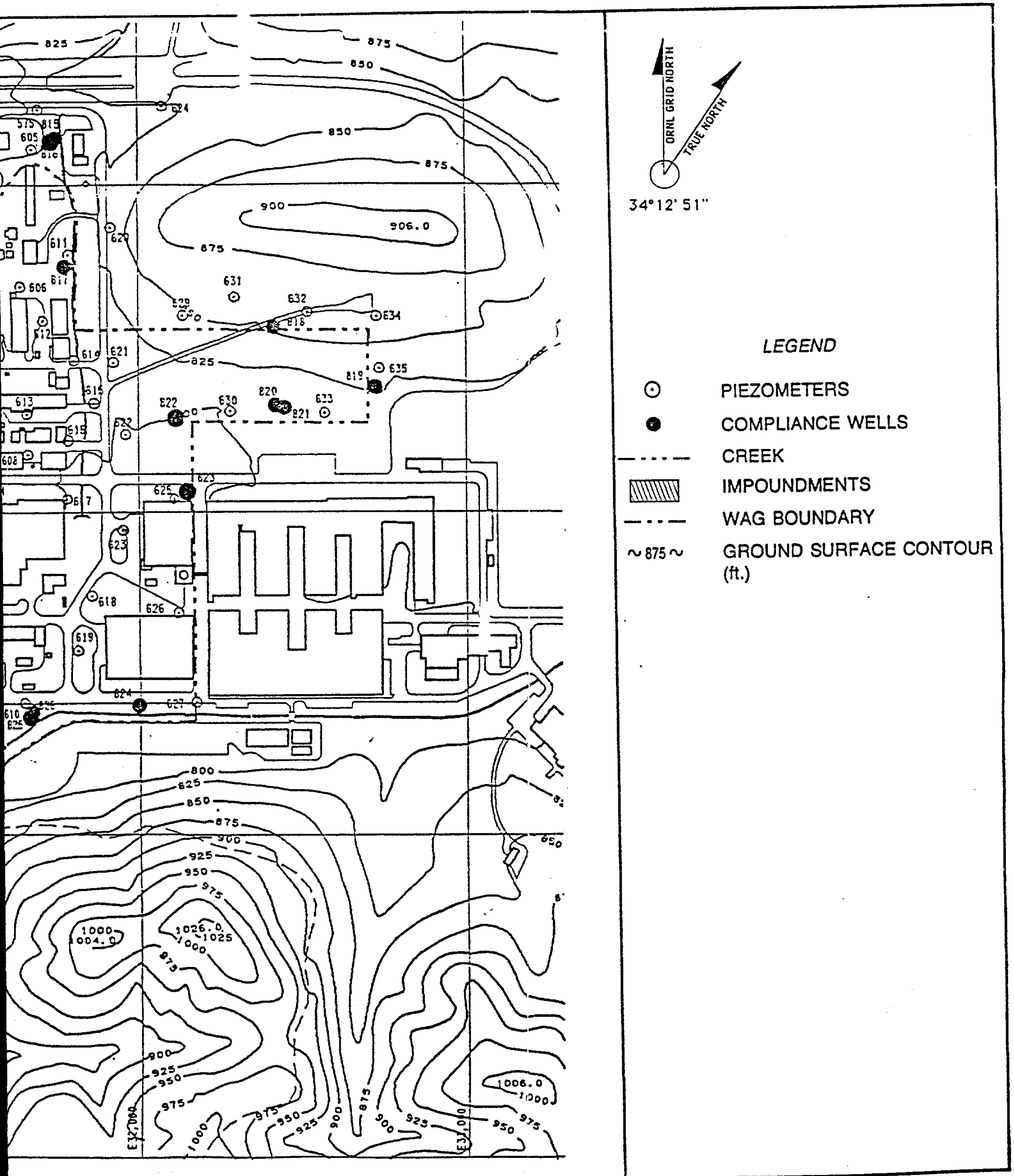


FIGURE A3-1
EXISTING PIEZOMETERS AND COMPLIANCE WELL LOCATIONS

reconnaissance during the preparation of this Field Sampling Plan indicates that some of the piezometers shown on Figure A3-1 are no longer evident and may have been destroyed during construction activities at the main plant. This will be confirmed during the well evaluation and headspace gas sampling activities. Gas samples will be collected from headspace prior to any other activities in the well. These gas samples will be analyzed for volatile organic constituents.

A3.2.2 Equipment and Procedures

Wells will be unlocked and sealed to permit the collection of gas in the wellbore. A probe will be inserted through a rubber stopper and into the top of the casing with aluminum foil separating casing from the rubber stopper. A low flow air pump is attached through teflon tubing to the probe and to a gas sample bag. Analyses of the gas will be done using a GC or equivalent to provide scoping data for the presence of volatile organics in groundwater. As appropriate, collection of samples will follow Method Number ESP-303-7, "Soil Gas Sampling" (Energy Systems, 1988).

A3.3 EVALUATION AND UPGRADE OF EXISTING WELLS, DRYWELLS, AND SUMPS

A3.3.1 Location, Number, and Tasks

Field reconnaissance of selected existing wells within WAG 1 and beyond the WAG 1 boundary will be conducted in coordination with the headspace gas analysis to evaluate their suitability for monitoring water levels and water quality during the RI. Up to 50 stainless steel compliance wells and 101 piezometers will be included in the evaluation. Existing well locations are shown in Figure A3-1.

Based on the results of the field evaluation and the headspace gas analysis, some wells may be upgraded to meet the standards set for this investigation. Well upgrading will involve well development and placement of a locking cap or locking sanitary seal, as required. It is anticipated that well development will be performed on up to 100 of the piezometers shown in Figure A3-1, and that locking caps will be installed on up to 50 of these wells to secure them for future sampling. The estimate of the number of existing wells to be developed during the RI assumes that compliance wells installed by ORNL have been developed by ORNL prior to startup of RI field activities.

During the well evaluation process drywells associated with the active and inactive waste and/or process tanks and sumps in building basements will be inventoried and checked for the presence of water flow or radiological or chemical constituent monitoring data. The drywells should provide meaningful data on the presence of contaminants in the fill immediately surrounding tanks and will provide information on the existence of leaks from those tanks into that fill.

Sumps may provide data on the presence of radionuclides and metals in groundwater in the vicinity of a certain building. While they may not provide much useful data on organics, they should provide useful information on shallow groundwater movement beneath WAG 1 and possibly some information on direction of flow.

Sumps and drywells will be located and field screened as part of this task and sampled, as required, as part of groundwater sampling task (Section A3.5).

A3.3.2 Equipment and Procedures

Field reconnaissance will include a visual inspection of selected wells, drywells, and sumps; observations will be recorded in a logbook. Observations will entail construction details including materials and dimensions; stickup above the ground surface for all casings and riser pipes; integrity of concrete pad at ground surface; and the presence or absence of such items as well caps, sanitary seals, locking caps and locks, and protector pipes. Any evidence of flooding of manholes and/or well locations susceptible to flooding by surface water runoff will require a more stringent evaluation.

Well development will be performed using a combination of surging and airlift pumping as described in Section A3.4.2. Locking caps will be provided for selected wells that currently do not have them. For wells completed above-grade, tabs will be welded to steel protector pipes and caps to facilitate placement of a lock to secure the well. For below-grade well completions, a locking sanitary seal will be installed. Care will be exercised to maintain the integrity of the annular and surface cement seals; however, at some locations, it may be necessary to replace the concrete pad at the surface.

A3.4 WELL DEVELOPMENT

A3.4.1 Location and Number

Well development must be performed on wells to be used as either water quality or water level monitoring stations during the investigation. It is assumed that all 25 RCRA compliance wells on the WAG 1 perimeter and the 17 impoundment monitoring wells have been adequately developed and will require no additional development prior to sampling. It is also assumed that none of the 101 piezometers and well points installed in and around WAG 1 have been developed. The purpose of development is to remove the influence of non-native materials on the well. Development will remove fluids that were introduced during drilling and sediments that entered the sandpack and screened zone during well installation. It also encourages the movement of geological formation waters through the well, thus decreasing the formation equilibration period.

A3.4.2 Equipment and Procedures

Well development will be performed using a combination of surging and air-lift pumping. The well will initially be surged with a surge block throughout the screened interval. This will be followed by air lift pumping throughout the screened interval, which will remove fine sediments and any water or other drilling fluids introduced during drilling. The air-lift pump apparatus will be constructed such that air is not directly forced into the formation. Wells will be developed until turbidity is significantly reduced and a sufficient number of well volumes have been removed.

The number of well volumes will depend on aquifer characteristics across the screened interval of the well, such as recovery, but will generally involve the removal of 10 well volumes. Method Number ESP-600, "Groundwater Sampling Procedures: Well Installation, Development, and Abandonment" (Energy Systems, 1988) will provide guidance in terminating well development at a given well. Disposal of water and sediments removed during development will be in accordance with the approved ORNL RI/FS Waste Management Plan (BNI, 1988a). All equipment used during well development will be decontaminated in accordance with Project Procedure 1250, "Equipment Decontamination and Release for Unrestricted Use" (BNI, 1988b), and Method Number ESP-900, "Cleaning and Decontaminating Sample Containers and Sample Devices" (Energy Systems, 1988).

A3.5 GROUNDWATER SAMPLING

A3.5.1 Objectives

Groundwater quality samples will be collected at the site to establish water geochemical characteristics and to investigate the types and concentrations of contaminants currently present in the groundwater. Water quality data will be used in the baseline health assessment to assess the potential for migration of contaminants from WAG 1 sources to potential receptors based on flow directions and rates, groundwater geochemistry, identified concentrations and extent of contaminants, and mobility and toxicity of identified contaminants.

A3.5.2 Locations, Frequency, and Analyses

The first groundwater sampling event will occur during the initial scoping of the site. The purpose of this event is to investigate the range of contaminants and concentrations at the site using, as a minimum, the existing monitoring well network and selected piezometers. Piezometers selected will be based on the headspace gas analysis and on qualified data from the initial piezometer sampling effort in 1986. Data from this activity are of limited value because the piezometers were not developed and the samples were not filtered prior to acidification and analysis. At present, 27 piezometers on WAG 1 are measured monthly for water level; 25 of those are also analyzed for temperature and specific conductance. These piezometers will be considered as candidate sites for development, sampling, and analysis. Thirty-nine water quality monitoring wells and 50 piezometers will be sampled and analyzed during the first round sampling activity. It is anticipated that this round of sampling will occur during seasonal low water table to provide baseline groundwater geochemical data for that hydrologic setting. Suitable wells have not yet been identified; however, the sampling locations will be selected from the subset of wells that meet the criteria described in Section A3.2.3. The well locations will be selected to provide coverage of the entire site and to provide water quality at locations expected to show or known to have shown contamination in the past. The locations of existing compliance wells and piezometers are shown on Figure A3-1; wells from which subsequent rounds of samples will be collected have not yet been identified.

Another sampling activity is planned to coincide with a major storm event during the low water table condition. It is anticipated that up to 90 wells selected from RCRA monitoring wells, existing piezometers, and possibly some new wells will be sampled during this activity. A period of not less than one week will have elapsed after any wells have been developed before any sampling event occurs to allow an equilibration period for formation water. Analytical parameters for these two activities are shown on Table A3-1.

A second set of sampling events will be timed to correspond to the high water table elevation on regional well hydrographs. This again will be separated into two sampling activities, one representative of base conditions and a second activity to represent the influence of a storm event on the high water table setting. Analytical parameters for these two activities are also shown on Table A3-1.

All groundwater samples will be analyzed for the parameters listed in Table A3-1. Field QC samples will be collected at the frequencies to satisfy Method Number ESP-400, "Field Quality Control" (Energy Systems, 1988). It is assumed for scoping purposes that field QC samples will be collected and analyzed at a combined rate of 10 percent.

A3.5.3 Equipment and Procedures

Groudwater samples will be collected using dedicated samplers for the water quality well network and samplers that have been decontaminated between each sampling location for the piezometer network. Collection of samples will occur as follows:

- Measure the water level in the well.
- In productive wells, purge the well by pumping, with simultaneous measurement of the pH, Eh, specific conductance, and temperature of the purged water.

TABLE A3-1

SUMMARY OF ANALYSES FOR GROUNDWATER SAMPLING PROGRAM

	Number of Analyses						
	Low Water Table			High Water Table			
	Base RCRA	Piez	Storm Event Select Wells	Base	Storm Event	QC[a]	Total
Field Analyses							
o Temperature	39	50	90	90	90	--	359
o pH	39	50	90	90	90	--	359
o Specific Conductivity	39	50	90	90	90	--	359
o Eh	39	50	90	90	90	--	359
o Beta/Gamma Scan	39	50	90	90	90	--	359
Laboratory Chemical Analyses							
o TCL (Attachment A-2)	39	--	--	39	--	8	86
o Miscellaneous Parameters (Attachment A-3)	39	50	90	90	90	36	395
o ICP Metals and Appropriate Organics	--	50	90	90	90	32	352
Laboratory Radiological Analyses							
o Gross Alpha	39	50	90	90	90	36	395
o Gross Beta	39	50	90	90	90	36	395
o Gamma Spectroscopy	39	50	90	90	90	36	395
o Alpha Emitting Isotopes[b]	39	25	45	45	45	36	235
o Beta Emitting Isotopes[b]	39	25	45	45	45	36	235

[a] For scoping purposes, it is assumed that QC samples analyzed will represent approximately 10 percent of the total samples collected.

[b] For scoping purposes, it is assumed that only 50 percent of piezometer samples will be analyzed for alpha and beta emitting isotopes.

- In less productive wells, purge the well by bailing with measurement of the pH, Eh, conductivity, and temperature at least once during each well volume.

- Collect the sample.

- Following collection, samples will be handled as described in Section A8.0.

Productive monitoring wells will be purged in accordance with Method Number ESP-302-2, "Groundwater Sampling Procedures: Guidelines for Well Purging" (Energy Systems, 1988). Guidance for sampling these wells using a teflon-lined positive displacement bladder pump can be found in Method Number ESP-302-5, "Groundwater Sampling Procedures: Using a Bladder Pump" (Energy Systems, 1988). The intake of the pump will be lowered to within a few inches of the bottom of the well and purged water will be passed directly from the discharge tubing of the pump into a chamber. Field parameters (pH, Eh, specific conductance, and temperature) will be measured in the chamber before the water contacts the atmosphere. Samples will be collected from the discharge tubing when the field parameters remain stable (±10 percent) over at least three well volumes of purged water. A well volume is defined as the volume of water contained in the well at the onset of pumping.

Less productive wells (i.e., those wells without sufficient flow for continuous pumping) will be purged and sampled using bottom loading stainless steel bailers in accordance with Method Number ESP-302-3, "Groundwater Sampling Procedures: Using a Bailer" (Energy Systems, 1988). The well will be bailed dry and allowed to refill prior to sample collection.

Aliquots to be analyzed for dissolved metals and radioactive constituents will be filtered in the field prior to preservation; aliquots for organic constituents will not be filtered in the field prior to preservation.

All equipment not dedicated to the well that contacts groundwater will be decontaminated in accordance with Project Procedure 1250, "Equipment Decontamination and Release for Unrestricted Use" (BNI, 1988b), and Method Number ESP-900, "Cleaning and Decontaminating Sample Containers and Sample Devices" (Energy Systems, 1988).

A3.6 WATER LEVEL MONITORING

A3.6.1 Objectives

Discrete water level measurements will be made in all suitable wells and at selected stream locations to obtain information used in the baseline health assessment to assess flow direction at the site and in investigating the relationship between groundwater and surface water flow regimes. In addition, continuous water level records will be obtained to observe the responsiveness of the aquifer to precipitation and changes in barometric pressure.

A3.6.2 Location and Frequency

Approximately four discrete water level measurements will be made for all wells that are in place during the designated measurement event and that meet the criteria described in Section A7.2. Water levels will be measured at the following times:

- Once prior to the well development water quality scoping event,
- Once following the completion of well installation and development, and
- Once during each of the two groundwater sampling events.

Continuous groundwater and/or surface water level measurements will be obtained for up to four weeks in each of up to 35 locations. Monitoring stations have not yet been determined; however, they will include monitoring well pairs. To scope the cost of this effort, it has been estimated that continuous water levels will be collected over a period of approximately 4 weeks, utilizing up to four microloggers equipped with multiplexers and/or multiple transducer hookups. A continuously recording digital barometer will be installed at the site throughout the period during which continuous water level measurements are made.

A3.6.3 Equipment and Procedures

Collection of any single round of discrete water levels will occur on the same day. Water levels in the streams adjacent to selected wells will also be measured during each sampling event. Water levels will be measured to the nearest 0.01 ft in accordance with Project Procedure 1638, "Water Level Measurements in Completd Wells" (BNI, 1988b), and Method Number ESP-302-1, "Groundwater Sampling Procedures: Water-Level Measurements Using Water-Level Indicator" (Energy Systems, 1988).

Continuous water levels will be collected using a CSI Model 21x micrologger, or equivalent, equipped with appropriately ranged transducers. Water level and barometric measurements will be electronically recorded at half-hour intervals. Data will be transferred from the micrologger memory to a hard disk at the end of each week, prior to setting up a new monitoring station. When surface water features are being recorded, the nearby well will be monitored concurrently. Water levels in surface impoundments will be measured once daily throughout the 4-week period.

All water level measuring instruments that contact groundwater will be decontaminated in accordance with Project Procedure 1250, "Equipment Decontamination and Release for Unrestricted Use" (BNI, 1988b), and Method Number ESP-900, "Cleaning and Decontaminating Sample Containers and Sample Devices" (Energy Systems, 1988). As they are removed from the well, all cables and probes will initially be wiped down using a cloth saturated with isopropyl alcohol. They will then be steam cleaned prior to transfer to another well or creek.

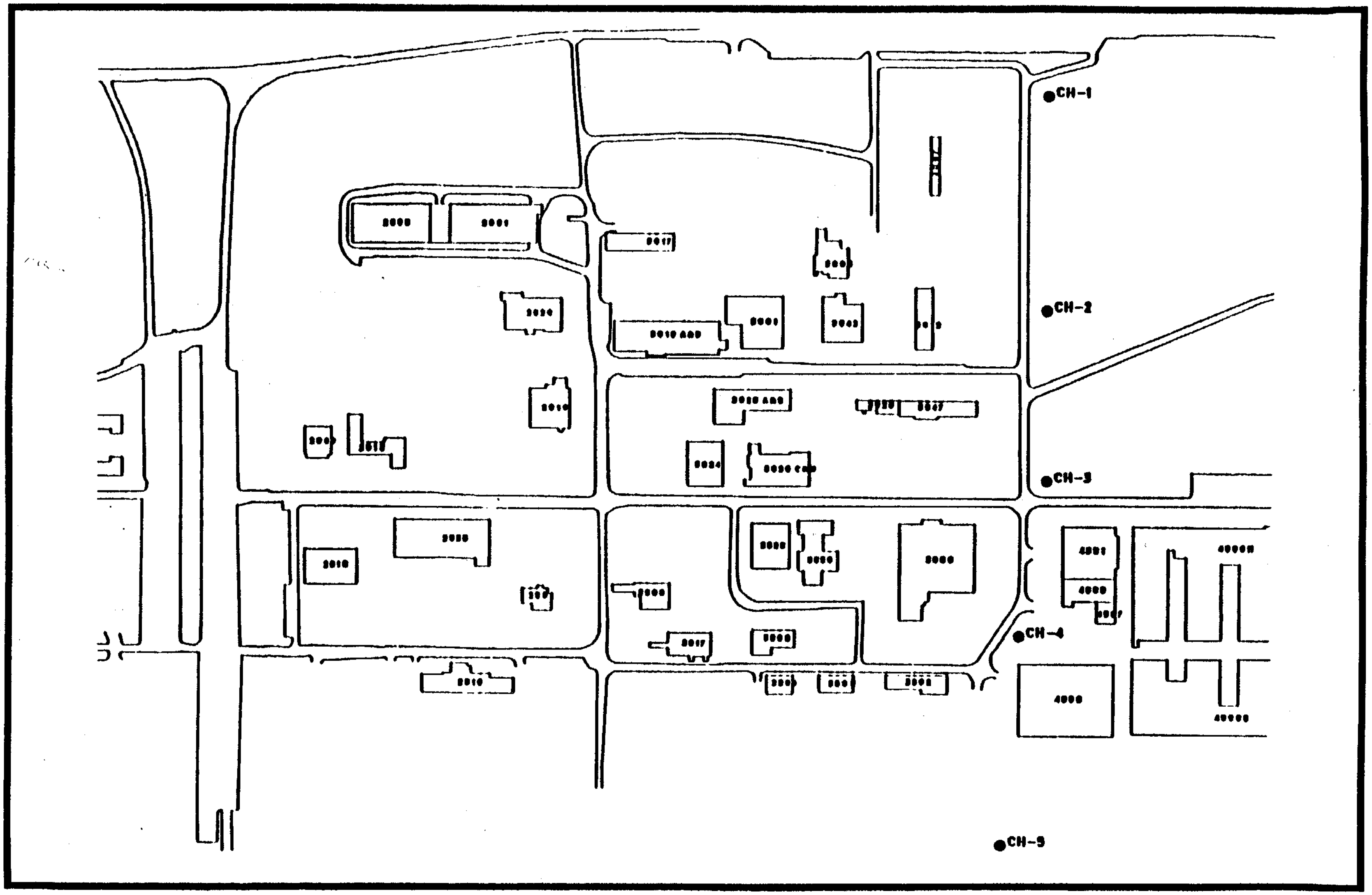
A3.7 DEEP COREHOLES TRANSECT

A3.7.1 Objectives

As a part of the initial RI activities, it is necessary to determine the interrelationship between the shallow (overburden) and the deeper (bedrock) flow systems. Several deeper coreholes drilled in WAG 1 yielded water under artesian pressure suggesting the potential for upward flow out of the bedrock. This suggests low potential for migration of contaminants from the water table aquifer to the deeper flow system. It is the objective of this activity to show the relationship between the water table and deeper flow systems and, to characterize the potential for contaminant migration into that deeper flow system, and to aid in the determination of contaminant movement. This information will be used in the baseline health assessment.

Five deep coreholes--one each in Chickamauga units B, C, D, E, and G--have already been drilled at the site (Figure A3-2). Work performed in these five existing coreholes included packer testing of selected fracture zones and unknown geophysical logging. Data from the work performed to date will be obtained and evaluated as a separate RI task. Based on the findings of this evaluation, modifications will be made, as appropriate, to the work identified in this section. It is assumed that: 1) the five coreholes still exist, and remain open and can be used in the future for geophysical logging and packer testing; 2) boring logs for each of the boreholes exist; and 3) rock core collected from these boreholes exists for visual observation.

Should testing in existing coreholes, along Fifth Creek confirm presence of gradients indicative of upward groundwater flow, two



SOURCE: Ketelle et al. (1986).

FIGURE A3-2
LOCATIONS OF COREHOLES DRILLED AT OAK RIDGE NATIONAL LABORATORY

additional transects may be installed to better understand areal distribution of vertical gradients.

A3.7.2 Location and Procedures

The five existing coreholes will be instrumented to permit long-term monitoring of hydraulic head using data loggers and pressure transducers or other appropriate equipment to permit determination of the hydraulic interrelationship between the various stratigraphic units in the Chickamauga and their individual responses to meteorological events (barometric pressure and precipitation). In addition, water samples from the individual units will be collected to determine the existence of natural unit specific geochemical signature in the water and presence or absence of contaminants. If these coreholes are unavailable, air rotary holes will be drilled adjacent to each of the five previously tested coreholes. Should the above testing provide useful data, two additional transects of up to five coreholes each will be installed--one along First Creek and the second on the divide between First and Fifth Creek, tentatively along Third Street.

By selecting these two transects, the test results can be checked for bias, which could be introduced by placing coreholes in stream drainage ways. The actual locations of these coreholes, should they be drilled, will be selected based on field reconnaissance of the area. If possible, existing wells will be included in these transects lessening the requirement for additional drilling.

Continuous split spoon sampling of the coreholes will be collected to refusal by advancing the borehole using hollow stem augers. Procedures used to collect soil samples are described in Section A6.0. Continuous bedrock coring or air rotary techniques will be used to progress the borehole below the permanent casing and up to a total depth of approximately 400 ft. The borehole would be installed vertically to ground surface and terminated within the Chickamauga Group or the Rome Formation. Total depths will be calculated from known dip/strike of the units and final field locations. Cores will be stored by ORNL for future observation and correlation. A gamma log of the boring will be performed to profile radioactivity.

An acoustic televiewer log will be taken in the completed borings, the purpose of which is to identify fracture zones within the bedrock. Fracture orientation information collected during this investigation will be plotted on stereonets and used to determine orientation of joints and fractures beneath the site.

Packer permeability testing will be performed in up to three zones in each of the nine deep coreholes. Permeability testing procedures will be similar to those described by Lozier and Pearson (1987). Intervals selected for packer testing will be determined based on the orientation and distribution of fractures. Selection of these test intervals will be made by the Project Hydrogeologist after interpretations and correlations have been made of rock cores and borehole geophysical and acoustic televiewer logs.

A4.0 SEDIMENTS

A4.1 OBJECTIVES

Past investigations have identified radionuclide and/or chemical contamination in the creeks and in some of the impoundments, as described in Section 3.3.1.3 of the RI Plan and Section A1.2 of this FSP. Contaminated sediments in the WOC floodplain within WAG 1 may constitute a significant exposure pathway or component of an exposure pathway for human exposure to contaminants.

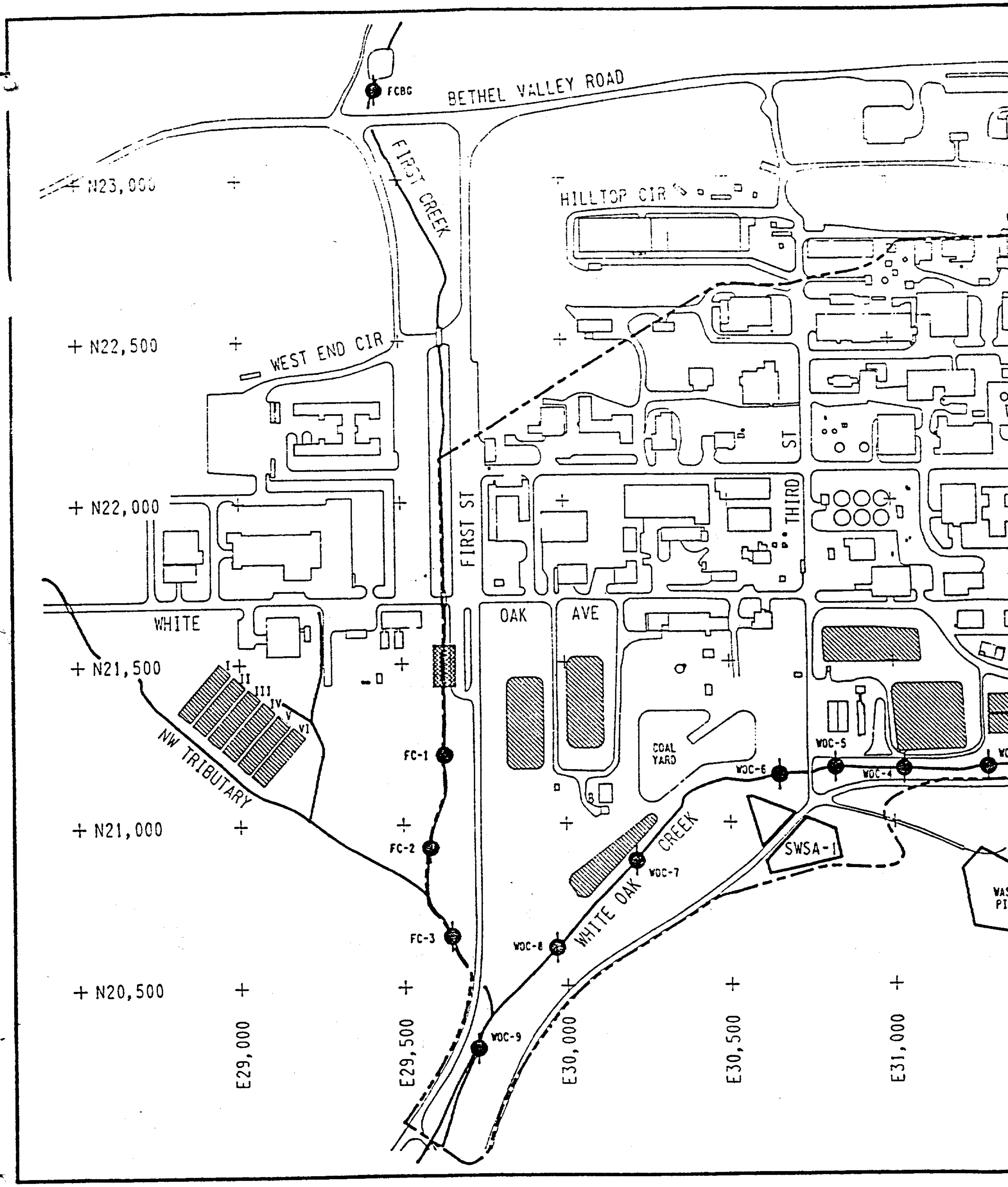
The objective of the WOC floodplain and impoundment sediment sampling programs is to supplement existing information for use in the baseline health assessment to identify the extent of contamination and receptor locations.

A4.2 WOC FLOODPLAIN SEDIMENTS

A4.2.1 Locations, Frequency, and Analyses

It is anticipated that one round of floodplain sediment sampling will be performed. One sample will be collected from each of the 14 locations shown in Figure A4-1 and from the WOC background station not shown in the figure.

White Oak Creek (WOC): The sediment sampling location WOC-1 was selected to provide information on accumulation of potential contaminants at the eastern edge of the WAG 1 boundary. This area is below the transformer station east of NPDES outfall 107, and above the area identified by Taylor (1989) as containing mercury contaminated sediments. Station WOC-2 is located at the junction of 5th Creek and WOC and will be used to determine the total movement of sediments for the 5th Creek branch. Stations WOC-3, WOC-4, and WOC-5 are adjacent to or downstream from three major process line discharges, 309, 305, and 301, respectively. These locations should provide some historical record of



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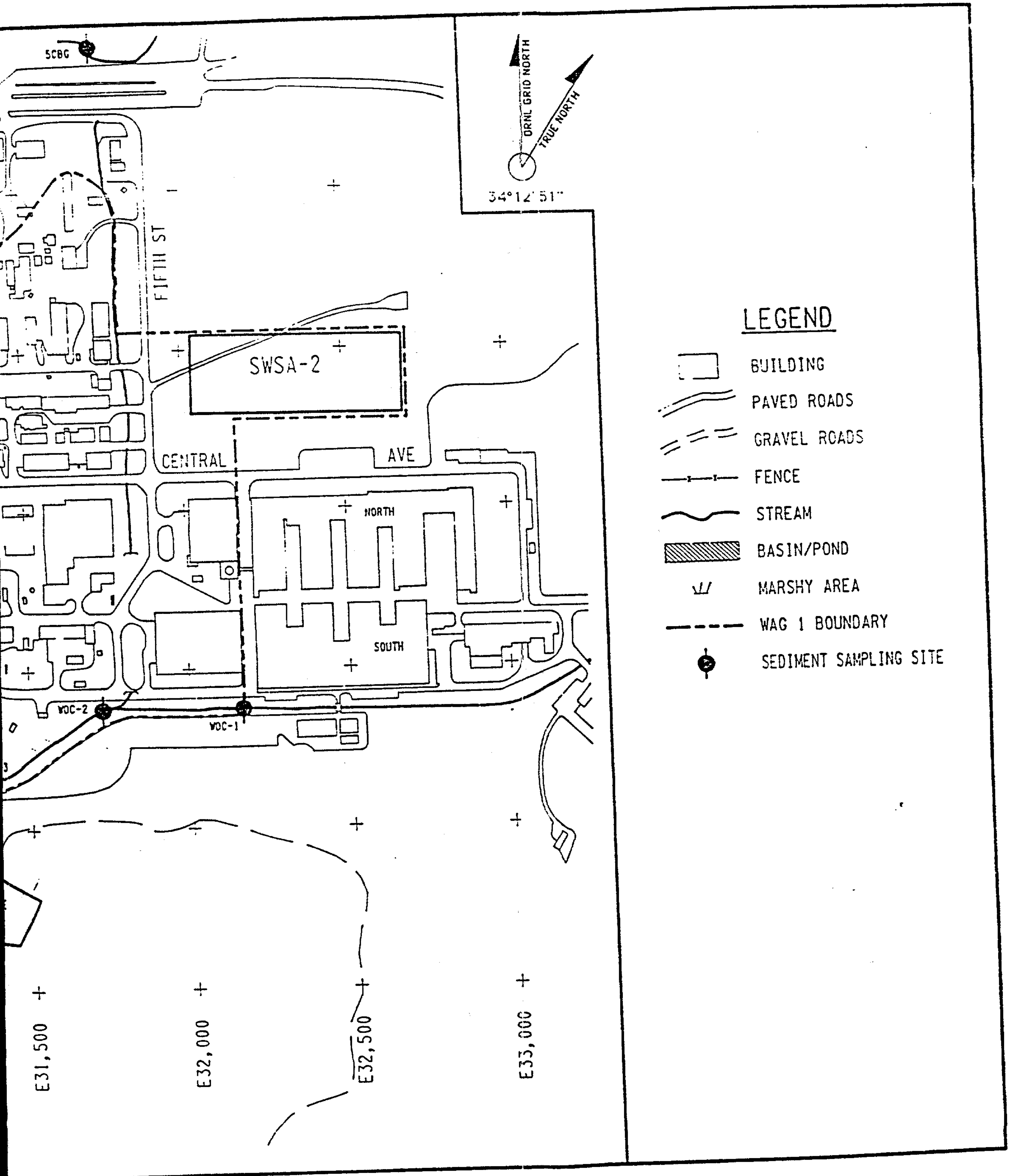


FIGURE A4-1
STREAM SEDIMENT SAMPLING
LOCATIONS

 (REV.1)

contaminants from these lines. The remaining four locations, WOC-6, WOC-7, WOC-8, and WOC-9 were selected to provide an estimate of the contaminants in the WOC floodplain in the area where the radiation levels are well above background.

The eastern edge of the contaminated floodplain was arbitrarily established at the crosswalk north of SWSA 1 (below WOC-5). The creek channel was divided into 80 20-ft segments, and a starting point was randomly selected by referring to a random number table between 1 and 20 segments (in this case the number 5, 100 ft below the crossing was selected). Sampling points 2, 3, and 4 were designated by adding 20 segments (or 400 ft) to the previously selected point, so that WOC-7 is 500 ft downstream of the crosswalk, WOC-8 is 900 ft downstream, and WOC-9 is 1300 ft downstream.

First Creek: A preliminary radiation survey of the creek by the BNI team revealed an area south of White Oak Avenue to be contaminated with Cs-137. This source area is shown by the hatch lines in Figure A4-1. The floodplain downstream of the area is also contaminated. The source area will undergo an extensive radiation walkover and subsequent sampling both in the creek area and in the adjacent area to the east. Sampling is discussed in the Soil Section A6.2. Sampling of the downstream floodplain designed to approximate that proposed for WOC. The creek was divided into 45 20-ft segments, and the first sampling location was randomly selected at the 220 ft point downstream (FC-1) of the source area. Subsequent sites were located at 520 and 820 ft as shown by FC-2 and FC-3, respectively (Figure A4-1).

Samples will be collected for analysis of radiological constituents and ICP metals (Table A4-1). Prior to submitting samples for metal analysis, x-ray fluorescence will be performed as a scanning technique. Some locations will have samples analyzed for potential organic contaminants pending results from the scoping surveys. In addition, creek sediments will be

TABLE A4-1

SUMMARY OF ANALYSES FOR CREEK CHANNEL SEDIMENT SAMPLING PROGRAM

Type of Analyses	Number of Analyses Primary	QC[a]	Total
Field Analyses			
o OVA/HNu	45	--	45
o Beta/Gamma Scan	45	--	45
o X-Ray Fluorescence	45	--	45
Laboratory Radiological Analyses			
o Gross Alpha	45[b]	5	50
o Gross Beta	45[b]	5	50
o Gamma Spectrometry	45[b]	5	50
o Alpha Emitting Isotopes	18[c]	2	25
o Beta Emitting Isotopes	18[c]	2	25
Laboratory Chemical Analyses			
o ICP Metals	45	5	50
o TCL Organics	15[d]	2	17

[a] For scoping purposes, it is assumed that QC samples will be collected at a rate of approximately 10 percent.

[b] For scoping purposes, it is assumed that an average of three samples will be collected at each site.

[c] For scoping purposes, it is assumed that 50 percent of samples will be analyzed for alpha and beta emitting isotopes.

[d] For scoping purposes, it is assumed that one sample per location will be analyzed for TCL organic compounds.

collected from the same locations selected for surface water samples as discussed in Section A5.0.

A4.2.2 Equipment and Procedures

At each sampling location described in Section A4.2.1, transects will be established on either side of the creek from the edge of the creek across the floodplain to its edge. Thus at each location, a north and south arm of a transect, running perpendicular to the stream flow, will be established. The number of sampling points along each transect area will be determined by the distance across the floodplain in the following manner:

Transect Arm Length		Sampling Points
< 3 m	(< 10 ft)	one at the edge of the floodplain,
3-9.1 m	(10-30 ft)	one at the edge of the floodplain plus one equidistant from the flood-plain edge and the creek bank,
9.1-30.5 m	(30-100 ft)	one at the edge of the floodplain plus two placed equidistant from the flood-plain edge and the creek bank, and
> 30.5 m	(> 100 ft)	one at the edge of the floodplain plus three placed equidistant from the flood-plain edge and the creek bank.

A maximum of eight sampling points will be established at locations where the total floodplain width is in excess of 61 m (200 ft). This design will provide an approximation of the horizontal extent of potential contaminants. An estimate of the vertical distribution will be accomplished by collecting samples to refusal or to bedrock in accordance with Method Number

ESP-303-5, "Subsurface Soil Sampling with Shelby Tubes" (Energy Systems, 1988).

A4.3 IMPOUNDMENT SEDIMENTS

A4.3.1 Locations, Frequency, and Analyses

Three sediment samples will be collected from each of the 2543 and 2544 impoundments. Sample locations will be selected by gridding each impoundment into 20 segments and selecting three at random for sampling.

Impoundment sediment samples will be analyzed for both chemical and radiological contaminants. Field analyses will include screening for volatiles with an OVA/HNu, determining pH, and beta/gamma radiation screening. Laboratory chemical and radiological analyses will be performed as described for the creek channel sediment samples. The analyses expected to be performed, on average, for each composite sample are summarized in Table A4-2. Field QC samples will be collected at the frequencies stated in Table A4-2.

Sufficient volumes of sediment, properly preserved and in appropriate containers, will be collected to enable all the analyses listed in Table A4-2 to be performed. Volume, preservation, and container requirements are specified in Section A8.0 of this FSP. The actual analyses to be performed will be specified by the responsible member of the BNI technical support group in accordance with the rationale provided in Section B9.2.1 of the QAPP.

A4.3.2 Equipment and Procedures

Impoundment sample aliquots will be collected using a hand corer fitted with extension handle. The corer will be forced with smooth, continuous motion to a depth of 1 ft, then twisted and

TABLE A4-2

SUMMARY OF ANALYSES FOR IMPOUNDMENT SEDIMENT SAMPLING PROGRAM

Type of Analyses	Number of Analyses: Primary	QC[a]	Total
Field Analyses			
o OVA/HNu	6	--	6
o Beta/Gamma	6	--	6
Laboratory Radiological Analyses			
o Gross Alpha	6	1	7
o Gross Beta	6	1	7
o Gamma Spectrometry	6	1	7
o Alpha Emitting Isotopes	3[b]	1	4
o Beta Emitting isotopes	3[b]	1	4
Laboratory Chemical Analyses			
o ICP Metals	6	1	7
o TCL Organics	6	1	7

(a) For scoping purposes, it is assumed that QC samples will be collected at a rate of approximately 10 percent, with a minimum of one sample for each type of analysis.

(b) For scoping purposes, it is assumed that 50 percent of samples will be analyzed for alpha and beta emitting isotopes.

withdrawn in a single, smooth motion. After the nose piece is removed, the aliquot will be extruded into a stainless steelbowl. If it is determined that a coring tool is inappropriate due to the depth/consistency of the sediments, or due to concerns relating to damage of synthetic liners, alternate aliquot collection techniques may be specified by the FSS Manager and WAG Manager.

Once the aliquots are collected and extruded into the bowl, they will be mixed to form a composite sample. The composite sample will be transferred to an appropriate sample container using a stainless steel spatula or spoon. Sample containers, preservation labeling, and chain of custody are described in Section A9.0.

Impoundment sediment sampling will be performed in accordance with applicable guidance described in Method Number ESP-304-1, "Sediment Sampling Procedures" (Energy Systems, 1988).

A5.0 SURFACE WATER

WOC and its tributaries constitute an integral part of both the surface and subsurface drainage of WAG 1. These creek waters plus surface waters in ORNL impoundments may constitute a significant exposure pathway or component of an exposure pathway for human and environmental exposure to contaminants.

The primary focus of the surface water sampling activity is to identify and provide data on the discharge areas associated with the major contaminant migration routes. As such it will be necessary to locate the sampling sites so that they can be sampled in conjunction with the groundwater/stormflow system. Therefore, the exact locations will not be selected until after these activities preceding the initial groundwater sampling event--sump and drywell surveys, headspace gas analysis, well evaluation and water level measurements.

An effort will be undertaken during or immediately following storm events to collect "opportunistic" samples from areas of interest. Potential sites will be selected on the basis of their ability to supplement routine data collection. As an example, the storm drain from the SWSA 2 area can provide data on migration of radionuclides from that area.

A5.1 CREEK FLOW MEASUREMENTS

The creek flow measurements will be used to aid in contaminant transport analysis in the baseline health assessment. Continuous flow monitoring capability already exists at Stations along WOC and First Creek. However, there is not one on Fifth Creek. A V-notch weir with a continuous stage recorder will be installed on Fifth Creek at a suitable location near the confluence with WOC. A staff gauge will also be installed to enable instantaneous readout of water stages. The weir will be field calibrated. Stream flows at the headwaters of First, Fifth, and

White Oak Creeks as well as at the other sampling stations will be taken from ORNL data collection programs. Flow at other locations will utilize a graduated cylinder/stop-watch method or a current velocity meter. The streams will then be surveyed to define their cross sections and water levels for use in discharge calculations.

The weir and staff gauge will be installed, calibrated, and operated in conformance with Method Number ESP-301-5, "Stream Flow Measurement" (Energy Systems, 1988).

A5.2 CREEK SAMPLING

A5.2.1 Locations, Frequency, and Analyses

The results from the creek sampling will be used in the baseline health assessment to aid in determining contaminant constituents and extent, the relationship between groundwater and surface water flow regimes, and identification of receptor locations. It is estimated that surface water samples will be collected from eight locations along the WAG 1 creeks with background samples collected as discussed in Section A7.0. Each location will be sampled to correspond with the groundwater sampling--once each during high and low water tables and during a storm event at both high and low water tables.

Sufficient volumes of surface water, properly preserved and in appropriate containers, will be collected to enable all the analyses listed in Table A5-1 to be performed. Volume, preservation, and container requirements are specified in Section A9.0 of this FSP. The actual analyses to be performed will be specified by the responsible member of the BNI technical support group in accordance with the rationale provided in Section B9.2.1 of the QAPP.

TABLE A5-1

SUMMARY OF CREEK SURFACE WATER SAMPLING

	Number of Analyses		
	Primary	QC[a]	Total
Field Analyses			
o pH	32	--	32
o Temperature	32	--	32
o Specific Conductivity	32	--	32
o Beta/Gamma Scan	32	--	32
Laboratory Radiological Analyses			
o Gross Alpha	32	7	39
o Gross Beta	32	7	39
o Gamma Spectroscopy	32	7	39
o Alpha Emitting Isotopes[b]	16	3	19
o Beta Emitting Isotopes[b]	16	3	19
Laboratory Chemical Analyses			
o TCL (Attachment A-2)	32	7	39
o Miscellaneous Parameters (Attachment A-3)	32	7	39

[a] For scoping, it is assumed that only up to 50 percent of samples will be analyzed for alpha and beta emitting radioisotopes.

[b] For scoping, it is assumed that QC samples will be collected at a combined rate of approximately 10 percent.

A5.2.2 Equipment and Procedures

Creek surface water sampling will be performed in accordance with Method Number ESP-301-5, "Stream Flow Measurement" (Energy Systems, 1988). Sample container preservation, labeling, and chain of custody are described in Section A9.0.

Samples from the background or headwater locations and from any ORNL downstream locations will be collected from existing sampling stations over a 24-h period and composited. Nonpoint source discharges will be collected as grab samples.

A6.0 SOILS

The soil sampling program is divided into three distinct activities:

- o Soils I - localized areas defined during the nondestructive surveys and well headspace gas analysis; these include spill and leak sites, SWSA 1, SWSA 2, and possibly the waste pile area.
- o Soils II - areas identified as a result of the creek sediment survey and the headspace analysis of existing wells; primarily these will involve defining major migration routes.
- o Soils III - those locations determined by the previous soil sampling activities to be source terms in need of more extensive definition.

The details of each phase of soil sampling are discussed in the following subsections.

A6.1 SOILS I

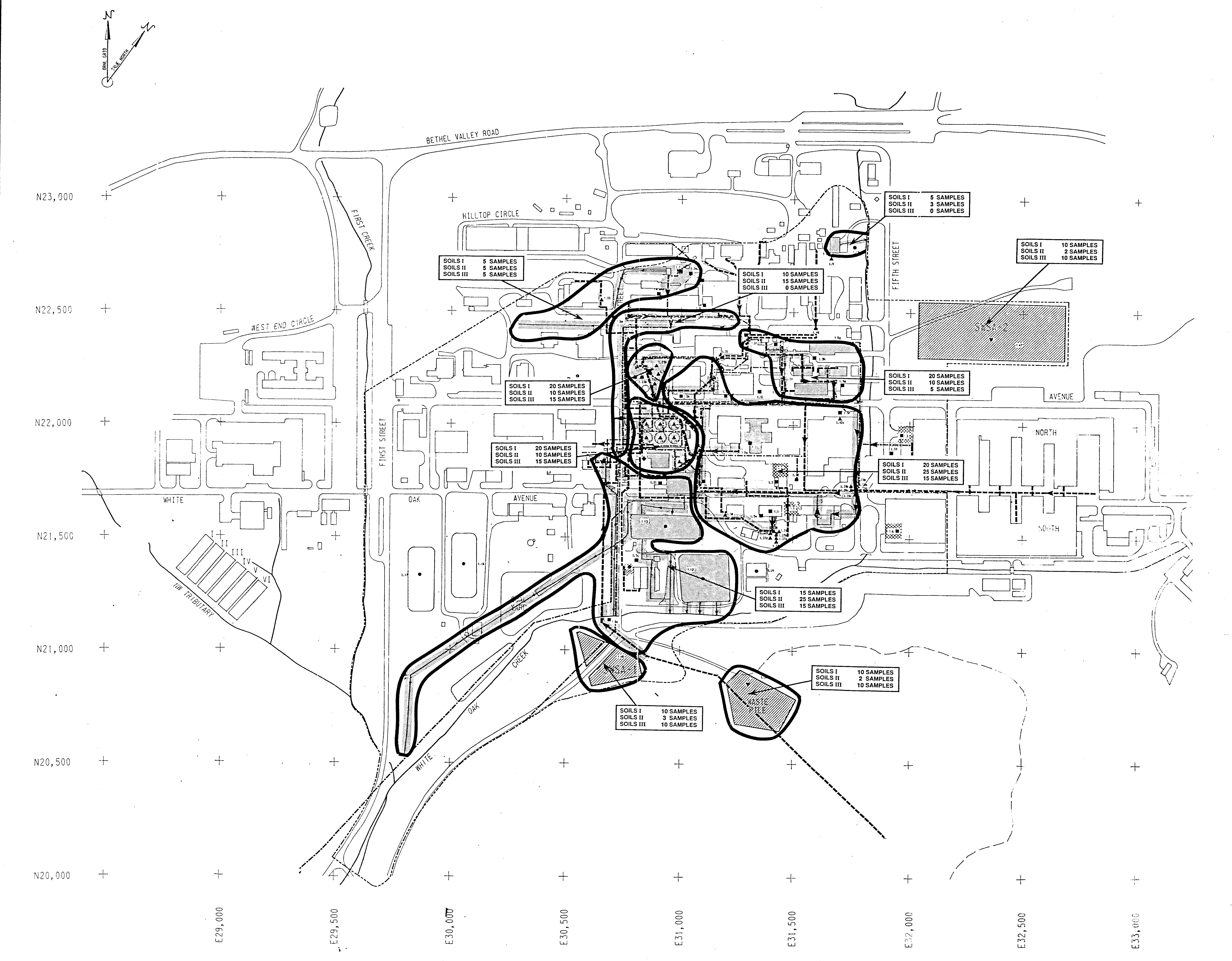
The exact sampling locations will be identified during the nondestructive surveys (Section A2.0) principally the radiological walkover, and the concomitant x-ray fluorescence survey, and the well headspace gas analysis. The results will be used in the baseline health assessment to aid in the identification of contaminants and determination of contaminant extent. The need for sampling will be based upon the area reading greater than 3 times background for radiation and/or a positive response for the x-ray fluorescence. It is anticipated that a total of 145 locations will be sampled during the Soils I activity. The estimated number of samples from various locations in WAG 1 are shown in Figure A6-1.

Selection of samples for organic analyses will be predicated on the proximity of or perceived importance of the location to an area already thought to be contaminated with organic compounds. In these areas a sample will be collected for both submission to

SIZE E

NOTES

1. TOPOGRAPHIC AND SITE SPECIFIC INFORMATION PROVIDED BY ENERGY SYSTEMS.
2. ORNL GRID
3. SWMU'S ARE APPROXIMATELY LOCATED.
4. AREAS OF CONTAMINATIONS ARE ESTIMATED BASED ON INFORMATION IN BOEGLY et al 1987, GRIMSLY, 1986a, AND GRIMSLY, 1986b.



INACTIVE LLW LINE

LLW WASTE SYSTEM

SANITARY OR STORM SEWER

CONTAMINATED AREAS ASSOCIATED WITH LLW / SYSTEM

MERCURY SPILLS

OTHER CONTAMINATED AREAS

LEGEND

BUILDING

PAVED ROADS

GRAVEL ROADS

FENCE

STREAM

WAG 1 BOUNDARY

SOLID WASTE MANAGEMENT UNITS

▲ COLLECTION & STORAGE TANK

▼ LAND DISPOSAL FACILITY

◆ WASTE TREATMENT FACILITY

■ LEAK OR SPILL SITE

● BASIN / POND

SWMU NUMBER

BECHTEL NATIONAL INC.
OAK RIDGE, TENNESSEE

FIGURE A6-1
NUMBER OF SOIL SAMPLING LOCATIONS GROUPED BY AREAS OF RADIOLOGICAL / CHEMICAL CONTAMINATION WITHIN WAG 1

A6-2

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the laboratory and for a field headspace analyses. Submission to the lab will depend upon the field analysis. Samples analyzed for organic compounds will be from the subsurface only, since the volatile and semivolatile constituents will have dissipated from the surface samples.

Routinely the number of samples for analysis will be based upon a determination of the areal extent of the contamination. The criteria for determining the number of samples needed to provide a valid estimate of the contamination was used by ORNL personnel during the DOE Environmental Survey, Table A6-1 (Murphy, 1989).

This criteria will be used in specifying the number of samples at each site. It is estimated that 175 samples will be collected from the 145 sampling locations during this Phase I activity. Of the 175 samples, it is estimated that 145 will be surface samples (0-45 cm) and 30 will be at a greater depth. The analytical breakdown is shown in Table A6-2.

A6.2 SOILS II

Ashwood, et al. (1988) have suggested that the shallow stormflow zone (root zone to 3-4 m) is the most important in transport of contaminants in and off of WAG 1. This suggestion is in keeping with the overall concept of material transport throughout the ORNL site. The controlling factors of flow in WAG 1 are the anthropogenic structures within this zone, most notably, the intricate pattern of pipeline trenches. These trenches run from a meter or less to 5-6 m from the surface and provide excellent conduits, via the backfill material, for contaminant migration. The purpose of the second soil sampling activity is to identify the extent of contamination, major migration routes, and subsequent contaminant source.

Information from the nondestructive groundwater analyses will be used to locate trenches to be used in the route tracking. The

TABLE A6-1

NUMBER OF SOIL SAMPLES PER AREA SIZE

Areal Size	Number of Samples
$<100\ m^2$	3
$100-500\ m^2$	4
$500-2500\ m^2$	5
$2500-12500\ m^2$	6
$12500-62500\ m^2$	7

TABLE A6-2

SUMMARY OF ANALYSES FOR SOIL SAMPLING PROGRAM

Type of Analysis	Number of Analyses: Soil Activity Level I	II	III	QC[a]	Total
Field Analyses					
OVA/HNU	175	100	100	38	413
Beta Gamma Scan	175	100	100	38	413
Laboratory Radiological Analyses					
Gross Alpha	175	100	100	38	413
Gross Beta	175	100	100	38	413
Gamma Spectrometry	175	100	100	38	413
Alpha Emitting Isotopes[b]	90	50	50	19	209
Beta Emitting Isotopes[b]	90	50	50	19	209
Laboratory Chemical Analyses					
ICP Metals	90	50	100	19	209
TCL Organics	45	25	100	17	192
Engineering Properties					
Atterberg Limits	--	--	100	--	100
Grain Size Analyses	--	--	100	--	100
o Mechanical Method					
o Hydrometer Method					
Unit Weight of Cohesive Soils	--	--	100	--	100
CEC	--	--	100	--	100
Kd	--	--	100	--	100

(a) For scoping purposes, it is assumed that a maximum of 50 percent of samples submitted for analysis will be analyzed for alpha and beta emitting isotopes.

(b) For scoping purposes, it is assumed that the QC samples will be collected at a rate of approximately 10 percent.

Cs-137 seep area on First Creek will be the initial sampling location (Section A4.2.1). There is a 24-in. stormdrain pipe less than 10 m to the north along the creek that may provide the route by which the radionuclide is transported. Soil samples will be collected using either a hand auger or truck mounted auger, whichever is most appropriate for the site. The use of the ORNL Atlas will provide approximate locations for the sampling effort. In addition to locating discharge areas along the Creeks by observation during the walkover survey, data from the building sumps and tank drywells may also indicate other areas within the main portion of WAG 1 where similar sampling can be initiated.

It is estimated that 100 locations will be sampled during this effort. The estimated number of sampling locations for this Soils II activity is based on the significant number of sources within each area as shown in Figure A6-1. The total number for each area is based on the extent of pipeline trenches in that area. Table A6-2 shows the number of analyses expected.

A6.3 SOILS III

The final soil sampling activity during Phase I of the RI will be the most extensive in terms of analytical requirements. Samples will be collected to provide data on individual SWMUs or operable units. Both source term identification and extent (for the baseline health assessment) and engineering property testing (for remedial alternative assessment) will be undertaken. This activity will be based on the findings of all previous investigations and will provide the basis for prioritizing remediation efforts. For scoping purposes, it is estimated that 100 locations will be sampled during this effort. The number of Soils III sampling locations in each area (Figure A6-1) is based on the anticipated number of significant sources within that area. Analytical requirements are shown in Table A6-2.

A6.4 EQUIPMENT AND PROCEDURES

A6.4.1 Areal Surface Composites

The composites of shallow subsurface soils will be composed of four aliquots per sample. In general, these aliquots will be taken from 3-ft squares superimposed on the sampling site. Collecting the aliquots from each corner of the 3-ft squares will provide maximum areal coverage per sample. The number of individual samples will be determined from Table A6-1. Each aliquot will be collected appropriately for the specific location, either with a stainless steel scoop or with a thin-walled Shelby tube.

Procedures will conform with Project Procedure 1634, "Sample Compositing and Duplicate Techniques" (BNI, 1988b), and Method Numbers ESP-303-1 through ESP-303-6 (Energy Systems, 1988).

Aliquots will be placed in a stainless steel bowl and composited by thorough mixing with a stainless steel spoon. After mixing, the composite will be transferred to the appropriate sample container (Section A9.0). Compositing procedures will be as specified in Project Procedure 1634, "Sample Compositing and Duplicate Techniques" (BNI, 1988b).

A6.4.2 Vertical Composites

Vertical composites will be formed from discrete segments (maximum 6 ft) of each borehole. Shallow boreholes (maximum depth 6 ft) generally will be drilled and sampled using a drill rig, as described below. However, in areas of difficult access, shallow holes may be drilled using a portable power auger or hand auger. The actual selection of equipment will be made by the WAG 1 Manager.

Aliquots for the vertical composites will be collected by three, 2-ft stainless steel split spoons taken from the 6-ft hole. A stainless steel spatula will be used to transfer approximately equal volumes of soil from each 2-ft segment from along the centerline of the core to a stainless steel bowl (e.g., in the event of 100 percent recovery in a 5-ft hole, the composite would be formed from 10 aliquots). The mixing of aliquots will be as specified for areal surface composites (Section A4.3.1). Aliquots for VOC analyses will be transferred directly to the sample container from the 2-ft stainless steel split spoon to minimize volatilization.

Drilling and sampling of all boreholes for which a drill rig will be used will be performed as follows. Boreholes will be advanced to refusal using hollow stem augers sized to accommodate the sampling tools and final purpose/completion of the borehole. At a minimum, the inside diameter of the auger will accommodate a 3-in. stainless steel splitspoon sampler, which will be used to meet the sample volume requirements prescribed by the analytical laboratory.

All samples and drill cuttings will be monitored in the field for organics and radioactivity. As each sample is recovered from the boring, it will be split open and laid out on a clean polyethylene tarp to avoid contaminating the soil sample. Health and safety-related monitoring of the sample will be performed; then, a record of the visual and manual inspection of the sample will be logged, including the grain size, moisture content, and Munsell color chart designation. Samples will then be composited as described above.

Specific guidance for drilling and sampling is found in Project Procedure 1634, "Sample Compositing and Duplicate Techniques" (BNI, 1988b), and Method Numbers ESP-303-1 through ESP-303-6 (Energy Systems, 1988). Guidance on specific procedures for equipment decontamination are detailed in Project Procedure 1250, "Equipment Decontamination and Release for Unrestricted Use" (BNI, 1988b), and Method Number ESP-900, "Cleaning and Decontaminating Sample Containers and Sampling Devices" (Energy Systems, 1988).

All borehole samples that are not submitted for analysis will be archived for possible future visual inspection or analysis. Specific archiving procedures can be found in Project Procedure 1605, "Sample Archiving" (BNI, 1988b).

A7.0 BACKGROUND SAMPLING

A7.1 OBJECTIVES

The objective for background sampling is to determine the natural levels of chemical and radiological constituents in the various environmental media at ORNL to permit the determination of anthropogenic contaminants into the environment.

The Main Plant, WAG 1, is underlain by limestone, siltstone, and shales of the Chickamauga Group. These rocks weather to clays containing variable amounts of chert. These clays consist primarily of a mixture of the minerals kaolinite and illite but significant smectite content may be found locally.

A7.2 LOCATION, FREQUENCY, AND ANALYSES

Surface Water: Surface water samples will be collected at locations to be selected upstream from WAG 1 on First Creek, Fifth Creek, Northwest Tributary and White Oak Creek. Three surface water samples will be collected during each of two events timed to occur during the high and the low of the regional stream hydrograph. Additional samples will be collected during selected storm events on an opportunistic basis.

These samples will be collected using Method Number ESP-301-1, "Water Sampling Using a Dipper" (Energy Systems, 1988), and will be analyzed for field parameters, TCL compounds, gross alpha, gross beta, and appropriate radionuclides.

Sediments: Sediments will be collected at the locations selected for surface water background sampling on a one-time basis. Each sample will be a composite of five grab samples taken along a transect across the stream bed to bedrock or a depth of approximately 1 ft. Each sediment sample will be analyzed for

TCL compounds, gross alpha, gross beta, and appropriate radionuclides.

<u>Soils/Bedrock</u>: The Chickamauga Group rocks that underlie WAG 1 have been subdivided into eight units designated A through H. Two soil borings should be located in the outcrop area of each unit to permit collection of residual soil samples from soil developed on each unit. These samples will be collected using splitspoon samplers and composited. Vertical composites of overburden (soil) material (maximum length 6 ft per composite) will be formed from stratigraphic units if identifiable in the splitspoon samples. Soil samples will be composited in accordance with the guidance provided in Project Procedure 1634, "Sample Compositing and Duplicating Techniques" (BNI, 1988b). Sampling will follow Method Number ESP-303-4, "Penetration Test and Split Barrel Sampling" (Energy Systems, 1988). The samples will be analyzed for TCL compounds, gross alpha, gross beta, and appropriate radionuclides.

One of the two borings located in each unit will be drilled into competent bedrock to a depth, determined by the field geologist, adequate to obtain an unweathered sample of bedrock. It is anticipated that less than 25 ft of coring will be required for each hole. Bedrock will be cored using appropriate core barrels and circulation fluid. Sampling will follow Method Number ESP-303-6, "Rock Coring and Sample Collection" (Energy Systems, 1988). The samples will be analyzed for TCL compounds, gross alpha, gross beta, and appropriate radionuclides.

<u>Groundwater</u>: To evaluate background conditions for groundwater chemistry, groundwater samples from both the soil and bedrock flow systems should be collected. Existing wells capable of supplying baseline groundwater chemistry samples should be identified and sampled; or, if such wells do not exist, monitoring wells should be established upgradient of WAG 1.

Wells will be installed to RCRA specifications using 2-in. stainless steel screen and riser pipe. Screen will be set at depths corresponding to transmissive intervals in the stratigraphic units of interest as selected by the project hydrogeologist utilizing packer test or similarly appropriate data. As an option, if appropriate locations can be identified, multiple completion wells utilizing Westbay, or equivalent completion systems, will be considered.

Samples will be collected quarterly for one year with two of the sampling events coordinated to correspond to high and low on the well hydrograph. Samples from the high and low water table sampling events will be analyzed for TCL compounds, gross alpha and gross beta, and appropriate radionuclides (including uranium isotopes, thorium isotopes, radium isotopes, potassium-40, tritium, and carbon-14). Samples from the remaining events will be analyzed for TCL metals, gross alpha and gross beta, and appropriate radionuclides.

Groundwater well installation, development, and sampling will be done in accordance with the project procedures and method numbers listed in Section A3.0.

<u>QC</u>: Appropriate QC samples (including duplicates, trip blanks, and equipment blanks) will be collected and submitted during each sampling event to conform with Method Number ESP-400, "Field Quality Control" (Energy Systems, 1988). Due to the importance of background data, all analyses will receive Level III CLP data validation, which will include complete CLP data validation packages.

A8.0 DOCUMENTATION OF FIELD ACTIVITIES

A8.1 FIELD LOGBOOKS

Field logbooks will be used for recording all activities performed during the WAG 1 RI. Entries will include sufficient detail to reconstruct significant activities without reliance on memory. Whenever a sample is collected or a measurement made, a description of the sample location will be recorded. All measurements and samples collected will be noted and, at the end of the day's activity, the book will be signed or initialed and dated by the author. Any deviations from the FSP or the QAPP will be noted and explained. Field logbook procedures are defined in Project Procedures 1501, "Data Collection, Encoding and Entry"; 1303, "Field Quality Control"; and 1631, "Logbook Protocols" (BNI, 1988b).

A8.2 PHOTOGRAPHS

Photographs will be taken of each impoundment sampled; of each surface water, sediment, and soil sampling location; of each boring location; and of each well installed. Additional photographs will be taken showing typical procedures for drilling, soil sampling, well installation, sediment sampling, surface water sampling, and groundwater sampling.

Each photograph will be logged in a field logbook. Each entry will include: the project name, project number, time, date, and location of the photograph; a description of objects in the photograph; the film roll and frame number; and the person taking the photograph. The film roll number will be identified by taking a photograph of an information sign number on the first frame of the roll.

For example:

WAG 1 RI
Roll No. 1
Frame 1 of 36
September 25, 1988 -- John Doe

Detailed guidelines for documenting field activities with photographs are described in Project Procedure 1110.1, "Field Photography and Control" (BNI, 1988b).

A9.0 SAMPLE CONTAINERS, PRESERVATION, LABELING, AND CHAIN OF CUSTODY

A9.1 SAMPLE CONTAINERS AND PRESERVATION

Sample volume requirements, preservation techniques, maximum holding times, and container material requirements are dictated by the media being sampled and by the analyses to be performed. Table A9-1 lists the requirements for samples collected and analyses specified in this FSP. As previously specified, field personnel will collect a sufficient volume of each sample in appropriate containers, properly preserved, to allow for all the analyses that may potentially be performed on each sample.

All sample containers, preservatives, and shipping crates/coolers will be supplied by the laboratory. Additional specific guidance on the appropriate use of these materials is provided in Project Procedures 1634, "Sample Containers and Preservation"; and 1501.6, "Sample Tracking Data Base" (BNI, 1988b) and in Analytical Laboratory Services Subcontract 19118-SC-04.

A9.2 SAMPLE LABELING AND CHAIN OF CUSTODY

All sample containers will be labeled, and chain of custody will be defined according to the procedures specified in Project Procedures 1501.6, "Sample Tracking Data Base"; and 1603, "Sample Information Management System." This project procedure will be used throughout the RI to guide the transmittal of information regarding collected samples to the analytical laboratory, the Data Base Supervisor, and other necessary parties.

TABLE A9-1

SAMPLE TYPES, CONTAINERS, AND PRESERVATIVES FOR WATER AND SOIL SAMPLES[a]

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity	Method of Shipment	Packing
Water	Inorganic Chemicals[b] - Anions	Two 1-liter polyethylene bottles	No	Iced to 4°C	28 days	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	o Nitrate	One 1-liter polyethylene bottle	No	Iced to 4°C	48 hours	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	o Sulfide	One 1-liter polyethylene bottle	No	Iced to 4°C Zinc acetate plus sodium hydroxide to pH > 9	7 days	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- TKN, TOC, Nitrate and Nitrite[b]	One 1-liter polyethylene bottle	No	H_2SO_4 to pH<2; Iced to 4°C	28 days	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- TDS[b]	One 1-liter polyethylene bottle	No	Iced to 4°C	48 hours	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	Radiological[c]	One 1-gallon polyethylene bottle	Yes	HNO_3 to pH<2	6 months	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	TCL[d] - Semi Volatiles	One 1-gallon amber glass jar	No	Iced to 4°C	7 days to extraction 40 days to analysis	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- Volatiles	Two 40-ml teflon lined glass (VOA) vial	No	Iced to 4°C	7 days	Fill to top, no air space	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- Dioxins	Two 1-liter amber glass jars	No	Iced to 4°C 0.008% $Na_2S_2O_3$	Do	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- Metals	One 1-liter polyethylene bottle	No	HNO_3 to pH<2 Iced to 4°C	6 months	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler

TABLE A9-1 (Continued)

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity	Method of Shipment	Packing
	- Cyanides	One 1-liter polyethylene bottle	No	NaOH to pH<12 Iced to 4°C	14 days	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- Pesticides/PCBs	One 1/2-gallon amber glass jar	No	Iced to 4°C	5 days to extraction 40 days to analysis	Fill to shoulder	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
Soil	- TCL[d] Metals, Semi-Volatile Organics, Pesticides /PCBs; Cyanide	One 1-liter teflon lined wide-mouth glass jar	No	Iced to 4°C	10 days	Fill to 3/4	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- TCL[d] Volatile Organics	One 40-ml teflon lined VOA vial	No	Iced to 4°C	10 days	Fill completely to minimize air space	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler
	- Radiological[c]	One 1-liter teflon lined wide mouth glass jar	No	Iced to 4°C	Depends on half-life; not to exceed 45 days	Fill to 3/4	Daily by exclusive use vehicle	Vermiculite or polyfoam cooler

[a]Subject to final review.

[b]For list of constituents, see Attachment A-2.

[c]For list of constituents, see Attachment A-3.

[d]For Target Compound List, (TCL) constituents see Attachment A-4.

A10.0 ANALYTICAL PROCEDURES

The specific QA objectives for all measurements taken are to obtain reproducible measurements with a degree of precision and accuracy consistent with the intended use of the data and the limitations of the equipment and analytical techniques used. This is accomplished through the assignment of measurement tasks to the appropriate analytical level (I through V) as defined in Data Quality Objectives for Remedial Response Activities (EPA, 1987a). Measurement task assignments to a specific analytical level are made based upon the use of the analytical data generated (i.e., field screening, site characterization, health and safety, risk assessment, evaluation of alternatives), and the analyte of concern.

The assigned analytical level dictates the equipment, methodologies, and protocols that must be applied as well as the data quality criteria regarding PARCC. Table A10-1 gives the analytical level to which WAG 1 measurement tasks have been assigned.

A10.1 FIELD ANALYSES

Analytical data to be collected for various media and the implementing procedures are listed in Table A10-2. Additionally, all samples will be screened for health and safety concerns as described in the ORNL RI/FS ES&H Plan (BNI, 1987b) and the WAG 1-specific ES&H Plan to be prepared prior to field work.

A10.2 LABORATORY ANALYSES

Analyses planned for WAG 1 samples include radionuclides, major ions, and the EPA's CLP TCL. All samples will be analyzed using EPA-approved methods. When EPA-approved methods are not available, or if a method requires modification, the method used will be thoroughly documented and proven to generate acceptable

TABLE A10-1

LEVEL OF ANALYSIS

REQUIRED ANALYTICAL LEVEL	TASK
Level I (Field Screens)	o pH measurement o Eh measurement o screening for organics (OVA/HNu) o screening for radionuclides (beta-gamma) o temperature o specific conductance o screening for buried objects (magnetometer, pipe locator)
Level II (Field Analyses)	o screening for organics (GC) o screening for metals (ICP) o screening for radionuclides (gross beta/gross alpha, gamma spec)
Level III (Laboratory Analyses using EPA Standard Methods)	o major ion analysis o organics analysis o inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	o analysis of TCL compounds
Level V (Nonstandard Analyses)	o radiological analyses o chemical analyses requiring modification of standard methods

Source: EPA (1987a).

TABLE A10-2

FIELD ANALYSES AND PROCEDURES FOR WAG 1

Analysis	Media			Procedure
	Surface Water	Groundwater	Soil/ Sediment	
pH	X	X	X	EPA Region IV SOPQAM Section 6.3.2[a]
Dissolved Oxygen	X	X	--[b]	EPA Region IV SOPQAM Section 6.3.3
Eh	X	X	--	EPA <u>A Compendium of Superfund Field Operations Methods</u>, Section 8.5.6.6.3 (EPA, 1987b)
Specific Conductance	X	X	--	EPA Region IV SOPQAM, Section 6.3.4
Temperature	X	X	--	EPA Region IV SOPQAM, Section 6.3.1
Organic Screens	X	X	X	EPA Methods[c]
Radiological Screens	X	X	X	IT <u>Radioanalytical Laboratory Procedures</u> (IT, 1987)

[a] SOPQAM-Standard Operating Procedures and Quality Assurance Manual (EPA, 1986c).

[b] The dash (--) indicates that this analysis is not applicable to this media.

[c] The specific technique and method will depend on the available field instrumentation.

results. The criteria for selecting specific methods is given in the Analytical Laboratory Services Subcontract 19118-SC-04.

A10.2.1 Rationale for Determining Chemical and Radiological Analyses

The following paragraphs provide information on the analytical strategy for radiological and chemical constituents during Phase 1 of the RI. This strategy will be reevaluated and revised for subsequent phases of the RI. Additional specifications for analyses are included in the FSP.

Radiological Analytical Strategy

The sample will be screened in the field for the presence of gamma radiation and in the close support laboratory for alpha and beta radiation and tritium. Unless radiation is detected, no further radiological analyses will be performed. However, if radiation is detected, appropriate isotopic analyses will be performed. The specific isotope analyses are detailed in Attachment A-3.

Chemical Analytical Strategy

Volatile Organic Compounds. At each sampling location designated in the FSP to be sampled for TCL compounds, two aliquots of the sample will be taken immediately and placed into VOA vials. A third aliquot will be taken, placed into a container (to be partially filled), and the headspace tested for VOCs with the HNu/OVA meter.

If a positive reading for VOCs is obtained by the HNu/OVA meter from the headspace gas or during the routine monitoring of the sample site, then the samples contained in the VOA vials will be analyzed for TCL volatile organics using GC/MS. If no volatiles are detected by the HNu/OVA field screen but the presence of volatiles is suspected or unknown, VOCs will be analyzed using a

GC screen. This determination is an assumption based upon best judgment and experience, knowledge of the sample area, and data trends.

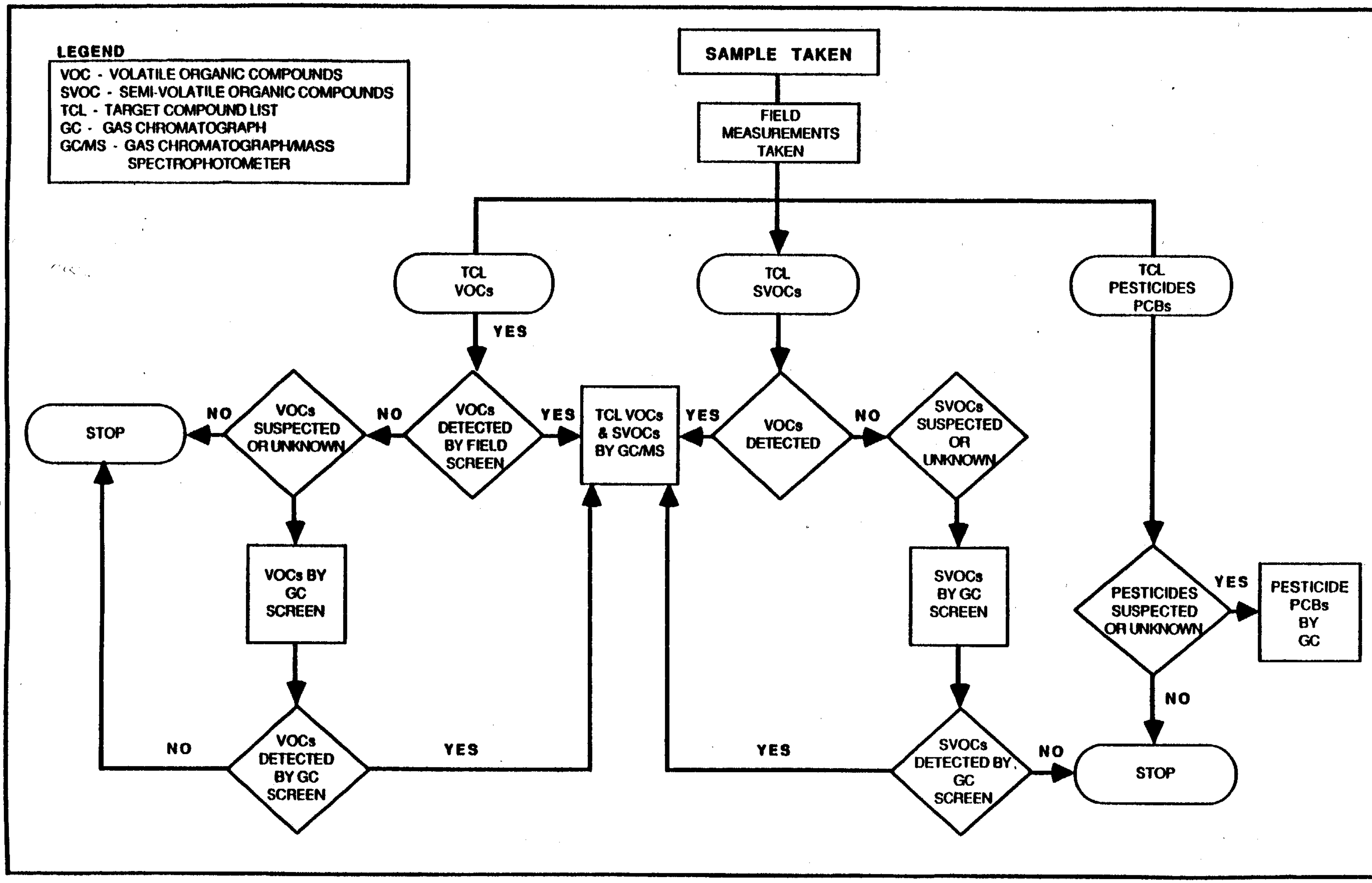
If a positive reading is obtained from the GC screen, then the sample will be analyzed by GC/MS for TCL volatile organics. If volatile organics are not detected during field screening or monitoring and if volatile organic contamination is not suspected in the area, the sample will not be analyzed for VOCs. The decision strategy for determining the most appropriate analytical procedures is shown in Figure A10-1.

Semi-Volatile Organic Compounds (SVOCs). The analytical strategy for SVOCs is similar to the strategy for VOCs and is depicted in Figure A10-1.

Pesticides/PCBs. Samples will be analyzed for pesticides and PCBs initially; however, continuation of the analysis will be determined by the WAG Manager based on data obtained from earlier samples. The analytical strategy is shown in Figure A10-1.

Metals (Excluding Mercury). Initially, an ICP scan will be performed on those samples selected for TCL analyses, as designated in the FSP, to determine what metals are present, if any, and in what concentration. Specified metals (i.e., arsenic, lead, selenium, and thallium) that are detected by the ICP scan at less than 5 times the Contract Required Detection Limit (CRDL) will require an additional confirmation analysis by atomic absorption.

The presence of mercury cannot be detected with the ICP screen. Mercury is analyzed using atomic absorption (cold-vapor method). Mercury will be analyzed initially, but will be eliminated from analytes if it is determined, with reasonable confidence, that it is not present at the site. The analytical decision scheme is shown in Figure A10-2. If less than three TCL metals are known



RIFS 4.3 0980.5 WAG 1

FIGURE A10-1
ANALYTICAL STRATEGY FOR ORGANIC TCL COMPOUNDS

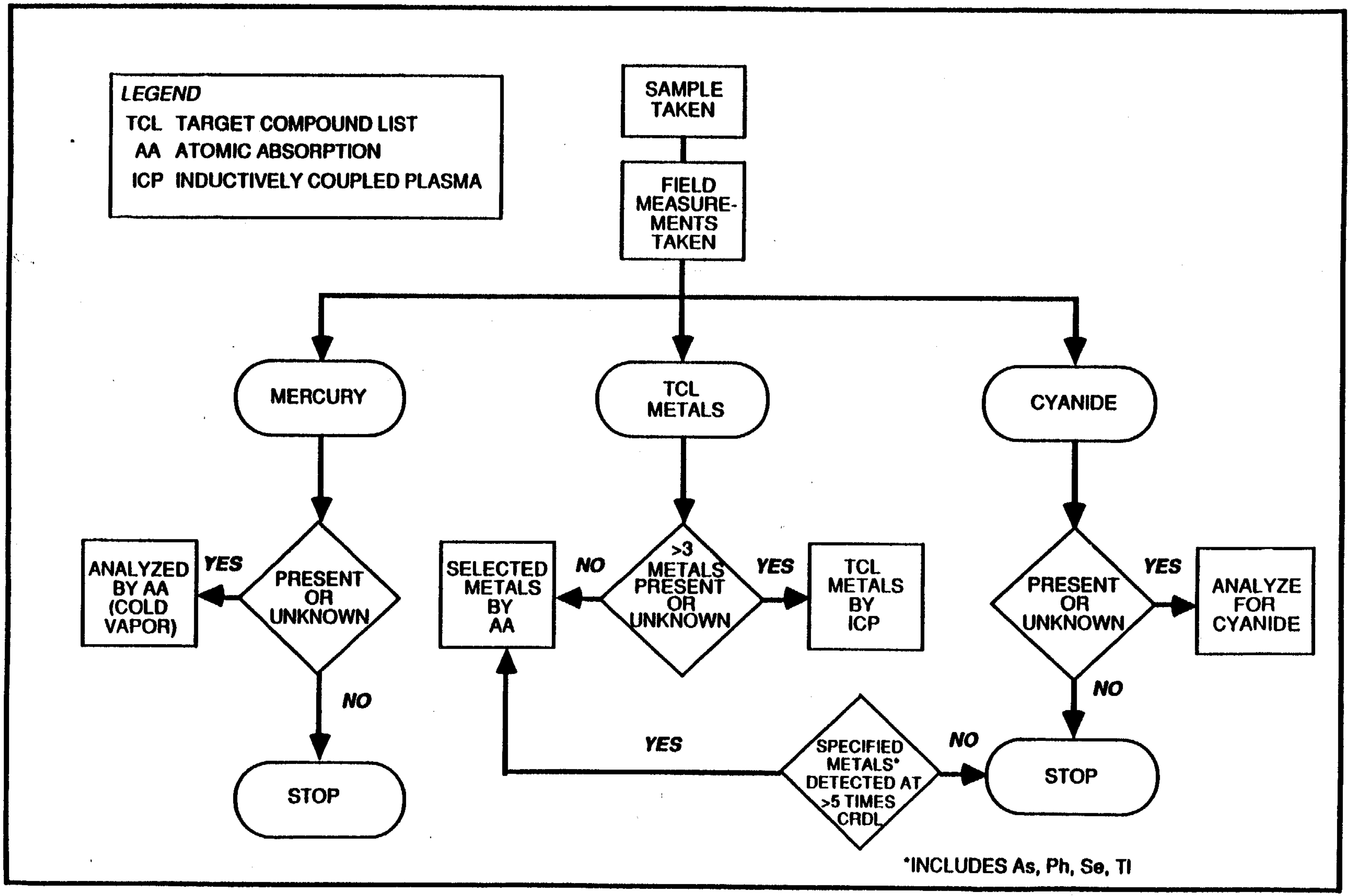


FIGURE A10-2
ANALYTICAL STRATEGY FOR INORGANIC TCL COMPOUNDS

to be present, then the metals will be analyzed using atomic absorption methods.

A11.0 WASTE VOLUME GENERATION

Due to the investigatory nature of the RI/FS process, it is anticipated that an iterative sampling approach will be necessary to adequately define the nature and extent of initially detected environmental contaminants. As a consequence, it is impossible to accurately predict volume, form, and content of wastes that are anticipated to result from WAG 1 field investigations. Table A11-1, however, provides estimates based on the currently projected investigation activities.

TABLE A11-1

ESTIMATED VOLUMES OF WASTES GENERATED DURING WAG 1
REMEDIAL INVESTIGATION

Waste Forms	Radioactive	Hazardous: RCRA	Hazardous: TSCA Only	Mixed	Conventional
1. SOLIDS					
o Soil (55-gal drums)	83	10	--	21	--
o Compactibles (55-gal drums)[a]	36	--	--	2	2
o Noncompactibles (55-gal drums)[b]	4	--	--	--	--
2. LIQUIDS					
o Decontamination Water (gal)[c]	9,345	220	--	1,305	--
o Well drilling/development fluids (gal)[d]	19,940	--	--	4,985	--
o Well Sampling (gal)[e]	33,400	--	--	8,350	--

[a]It is assumed that two drums per week of compactibles (plastic sheets, tyveks, gloves, etc.) will be collected. Five percent are assumed to be conventional waste; ninety percent are assumed to be radiological waste; and five percent are assumed to be mixed waste. Forty-eight working weeks are assumed per year.

[b]Noncompactibles consist of split spoons, buckets, etc., that cannot be decontaminated.

[c]Water used for decontaminating drilling equipment associated with water quality wells; 265 gals/day for 150 days.

[d]The total volume used for well development fluids is calculated using 5 well volumes per well.

[e]Based on three purging volumes per sampling events for three different events.

ATTACHMENT A-1

FIELD ANALYSES

MEDIUM	ANALYSIS
Air	OVA HNu
Sediment and Soil	pH OVA HNu Gamma Borehole Logging Beta-Gamma Scan
Surface Water and Groundwater	Temperature pH Eh Specific Conductance Beta-Gamma Scan

ATTACHMENT A-2

MISCELLANEOUS WATER QUALITY PARAMETERS/ANALYSES

ANIONS

Bicarbonate
Bromide
Carbonate
Chloride
Fluoride
Iodine
Nitrate
Phosphate
Sulfate
Sulfide

OTHER

Total Organic Carbon
Total Kjeldahl Nitrogen
Total Dissolved Solids

ATTACHMENT A-3

RADIOLOGICAL CONSTITUENTS

- Initial Gross Alpha/Beta Scan
- Further Analyses:

Gamma Spectroscopy	Alpha Spectroscopy	Beta Emitter[a] Isotopic
Potassium-40[b]	Radium-226	Tritium
Nickel-59	Thorium-230[c]	Carbon-14
Cobalt-60	Thorium-232[c]	Potassium-40[b]
Ruthenium-106	Uranium-233[c]	Strontium-90
Cesium-137	Uranium-234[c]	Technetium-99
Europium-152	Uranium-235[c]	Iodine-129
Europium-154	Uranium-236[c]	
Europium-155	Neptunium-237	
Radium-226	Uranium-238[c]	
Uranium-233	Plutonium-239[c]	
Uranium-235	Plutonium-240[c]	
Neptunium-237	Americium-241	
Californium-252	Curium-244[c]	
	Curium-245[c]	
	Californium-252	

[a] Determined by liquid scintillation.
[b] Concerned primarily as an interferant/natural radioisotope.
[c] Determined by isotopic analysis (e.g. "isotopic uranium").

ATTACHMENT A-4

TCL CHEMICAL CONSTITUENTS

TCL Parameter	CAS Number	Estimated[a, b] Detection Limits Water mg/L	Soil/Sediment mg/kg
VOLATILE ORGANICS			
Chloromethane	74-87-3	10	10
Bromomethane	74-83-9	10	10
Vinyl Chloride	75-01-4	10	10
Chloroethane	75-00-3	10	10
Methylene Chloride	75-09-2	5	5
Acetone	67-64-1	10	10
Carbon Disulfide	75-15-0	5	5
1,1-Dichloroethene	75-35-4	5	5
1,1-Dichlorethane	75-35-3	5	5
2-Chloroethyl vinyl ether	110-75-8	10	10
Trans 1,2-Dichloroethene	156-60-5	5	5
Chloroform	67-66-3	5	5
1,2-Dichloroethane	107-06-2	5	5
2-Butanone	78-93-3	10	10
1,1,1-Trichloroethane	71-55-6	5	5
Carbon Tetrachloride	56-23-5	5	5
Vinyl Acetate	108-05-4	10	10
Bromodichloromethane	75-27-4	5	5
1,1,2,2-Tetrachloroethane	79-34-5	5	5
1,2-Dichloropropane	78-87-5	5	5
Cis 1,3-Dichloropropene	10061-01-5	5	5
Trans 1,3-Dichloropropene	10061-02-6	5	5
Trichloroethene	79-01-6	5	5
Benzene	71-43-2	5	5
Bromoform	75-25-2	5	5
2-Hexanone	591-78-6	10	10
4-Methyl-2-Pentanone	108-10-1	10	10
Dibromochloromethane	124-48-1	5	5
1,1,2-Trichloroethane	79-00-5	5	5
Tetrachloroethene	127-18-4	5	5
Toluene	108-88-3	5	5
Chlorobenzene	108-90-7	5	5
Ethyl Benzene	100-41-4	5	5
Styrene	100-42-5	5	5
Xylenes (Total)	133-02-7	5	5
SEMI-VOLATILES			
N-nitrosodimethylamine	62-75-9	10	330
Phenol	108-95-2	10	330
Aniline	62-53-3	10	330
Bis (2-Chloroethyl) Ether	111-44-4	10	330

TABLE A-4 (Continued)

TCL Parameter	CAS Number	Detection Limits Water mg/L	Soil/Sediment mg/kg
2-Chlorophenol	95-57-8	10	330
1,3-Dichlorobenzene	541-73-1	10	330
1,4-Dichlorobenzene	106-46-7	10	330
Benzyl Alcohol	100-51-6	10	330
1,2-Dichlorobenzene	95-50-1	10	330
2-Methylphenol	95-48-7	10	330
Bis(2-Chloro Isopropyl) Ether	39638-32-9	10	330
4-Methylphenol	106-44-5	10	330
N-Nitroso-Dipropylamine	621-64-7	10	330
Hexachloroethane	67-72-1	10	330
Nitrobenzene	98-95-3	10	330
Isophorone	78-59-1	10	330
2-Nitrophenol	88-75-5	10	330
2,4-Dimethylphenol	105-67-9	10	330
Benzoic Acid	65-85-0	50	1600
Bis(2-Chloroethoxy)methane	111-91-1	10	330
2,4-Dichlorophenol	120-83-2	10	330
1,2,4-Trichlorobenzene	120-82-1	10	330
Naphthalene	91-20-3	10	330
4-Chloroaniline	106-47-8	10	330
Hexachlorobutadiene	87-68-3	10	330
4-Chloro-3-Methylphenol	59-50-7	10	330
2-Methylnaphthalene	91-57-6	10	330
Hexachlorocyclopentadiene	77-47-7	10	330
2,4,6-Trichlorophenol	88-06-2	10	330
2,4,5-Trichlorophenol	95-95-4	50	1600
2-Chloronaphthalene	91-58-7	10	330
2-Nitroaniline	88-74-4	50	1600
Dimethyl phthalate	131-11-3	10	330
Acenaphthylene	208-96-8	10	330
2,6-Dinitrotoluene	606-20-2	10	330
3-Nitroaniline	99-09-2	50	1600
Acenaphthene	83-32-9	10	330
2,4-Dinitrophenol	51-28-5	50	1600
4-Nitrophenol	100-02-7	50	1600
Dibenzofuran	132-64-9	10	330
2,4-Dinitrotoluene	121-14-2	10	330
Diethyl Phthalate	84-66-2	10	330
4-Chlorophenyl Phenylether	7005-2-3	10	330
Fluorene	86-73-7	10	330
4-Nitroaniline	100-01-6	50	1600
4,6-Dinitro-2-Methylphenol	534-52-1	50	1600
N-Nitroso-Diphenylamine	86-30-6	10	330
4-Bromophenyl Phenyl Ether	101-55-3	10	330
Hexachlorobenzene	118-74-1	10	330
Pentachlorophenol	87-86-5	10	330

TABLE A-4 (Continued)

TCL Parameter	CAS Number	Detection Limits Water mg/L	Soil/Sediment mg/kg
Phenanthrene	85-01-8	50	1600
Anthracene	120-12-7	10	330
Di-N-Butylphthalate	84-74-2	10	330
Fluoranthene	206-44-0	10	330
Pyrene	129-00-0	10	330
Benzidine	92-87-5	50	1600
Butyl Benzyl Phthalate	85-68-7	20	660
3,3-Dichlorobenzidine	91-94-1	10	330
Benzo(a)Anthracene	56-55-3	10	330
Chrysene	218-01-9	10	330
Bis(2-Ethylhexyl)Phthalate	117-81-7	10	330
Di-N-Octyl Phthalate	117-84-0	10	330
Benzo(b)Fluoranthene	205-99-2	10	330
Benzo(k)Fluoranthene	207-08-9	10	330
Benzo(a)Pyrene	50-32-8	10	330
PESTICIDE/PCB			
Indeno(1,2,3-cd)pyrene	193-39-5	10	330
Dibenz(a,h)Anthracene	53-70-3	10	330
Benzo(g,h,i)Perylene	191-24-2	10	330
Alpha-BHC	319-84-6	0.05	2.0
Beta-BHC	319-85-7	0.05	2.0
Delta-BHC	319-86-8	0.05	2.0
Gamma-BHC	58-89-9	0.05	2.0
Heptachlor	76-44-8	0.05	2.0
Aldrin	309-00-2	0.05	2.0
Heptachlor Epoxide	1024-57-3	0.05	2.0
Endosulfan I	959-98-8	0.05	2.0
Dieldrin	60-57-1	0.10	4.0
4,4'-DDE	72-55-9	0.10	4.0
Endrin	72-20-8	0.10	4.0
Endrin Aldehyde	7421-93-4	0.10	20.0
Endosulfan II	33213-65-9	0.10	4.0
4,4'-DDD	72-54-8	0.10	20.0
Endosulfan Sulfate	1031-07-8	0.10	40.0
4,4'-DDT	50-29-3	0.10	20.0
Endrin Ketone	53494-70-5	0.10	20.0
Methoxychlor	72-43-5	0.5	20.0
Chlordane	57-74-9	0.5	20.0
Toxaphene	8001-35-2	1.0	20.0
Aroclor 1016	12674-11-2	0.5	40.0
Aroclor 1221	11104-28-2	0.5	40.0
Aroclor 1232	11141-16-5	0.5	
Aroclor 1242	53469-21-9	0.5	
Aroclor 1248	12672-29-6	0.5	